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THE SPANISH GUNBOATS.

From the "Army and Navy Journal."

The annals of naval construction probably furnish no instance of greater diligence than that displayed in the production of the thirty Spanish gunboats now floating on the Hudson. The planning having been intrusted to Captain Ericsson, the contract for building the fleet was entered into with the Delamater Iron Works, in this city, on the 3d of May, 1869. On the 19th of May the first keel was laid, and on the 23d of June the first vessel was launched from Pouillon's shipyard, 34 working days after laying the keel. September 3d, just four months from the signing of the contract, and three months sixteen days after laying the first keel, the last vessel of this fleet was launched, at which time fifteen of the vessels previously launched had engines and boilers on board! Captain Rafael de Aragon of the Spanish navy, under instructions from Admiral Malcampo, the naval commander of the Spanish-Cuban fleet, superintends the equipment. Captain Aragon is favorably known in hydrographical circles for his accurate surveys of the Cuban coast.

The Spanish gunboats are sea-going twin-screw vessels, 107 ft. long on the water-line, 22 ft. 6 ins. extreme beam, 8 ft. depth of hold, and draw 4 ft. 11 ins. when fully equipped for service with coal, stores, and ammunition for 100 rounds on board. The lines at the bow are somewhat full in order to sustain a heavy bow-gun, the breadth of the deck being carried well forward for the purpose of facilitating the manipulation of this gun—of which we will speak presently. The run is very clean, the lines being deemed faultless for a twin-screw vessel. The construction of the hull presents two novelties worthy of special mention. The apparently insoluble character of the problem—a gunboat of this class drawing only 59 ins. of water when fully equipped for service—compelled the designer to dispense with the keel. Shipbuilders, it appears, at first objected to this innovation, but now admit that these gunboats may take ground with far less risk of straining and leaking than ordinary light-draught vessels with weak keels. The other novelty alluded to is the cutting down the rail and substituting a low, heavy timber bulwark at the bow, provided with substantial waterways and lined with sheet-iron to admit of firing the gun *en barbette*.

In addition to their ample steam power, the Spanish gunboats carry full amount of canvas, being schooner-rigged, with yard and square-sail on the foremast. Wire rigging having been adopted and the masts and smoke-pipe raked more than usual, the appearance of these twin-screw vessels is peculiarly light and saucy. Considering their great number, swiftness, light draught, and the long range of their guns, it is evident that the Spaniards will be enabled for the future to prevent

effectually, incursions on the Cuban coast.

As might be expected, the *steam machinery* of these novel war-vessels presents features of special interest. It has frequently been urged as an objection against the twin-screw system, that the double set of engines, four steam cylinders, with duplicates of all their working parts, called for on this system, render the whole too complicated and heavy for small vessels; preventing at the same time the application of *surface condensation*. The designer has overcome these objections by introducing a surface condenser, which, while it performs the function of condensing the steam to be returned to the boiler in the form of fresh water, serves as the principal support of the engines, dispensing entirely with the usual framework. Besides this expedient, each pair of cylinders have their slide-frames for guiding the movement of the piston rods, cast in one piece. Altogether, the combination is such that the total weight and the space occupied by these novel twin-screw-engines do not exceed the ordinary single-screw engines of equal power. Several improvements connected with the working gear have also been introduced. The outer bearings of the propeller shafts, always difficult to regulate and keep in order on the twin-screw system, are self-adjusting and accommodate themselves to every change of the direction of the shafts. This is effected by their being spherical externally, and resting in corresponding cavities in the stern braces or hangers. The "spring bearings," for supporting the middle of the shafts, are also arranged on a similar self-adjusting principle. The thrust bearing, which receives the pressure of the propeller, is a peculiar construction, the arrangement being such that the bearing surfaces remain in perfect contact, however much the shaft may be out of line. The reversing gear, likewise, is quite peculiar, insuring complete control over the movement of the two propellers under all circumstances. It is claimed that these engines are the lightest and most compact yet constructed for twin-screw vessels.

The internal arrangements and fittings show thorough knowledge and experience on the part of the superintending officer. Our friends on the Baltic who pride themselves on knowing more about gunboats than other nations, will be astonished when they learn how the Spaniards fit out such vessels. Indeed the equipment more resembles that of a yacht than that needed for a plain gunboat. We cannot afford space for a specification, and therefore proceed to notice only that which is essential. The coal bunkers are placed on each side of the boiler, extending equally forward and aft of the centre of displacement of the vessel, in order to preserve perfect trim whether the bunkers are full or empty. The magazine, located in the centre of the vessel between the engine-room and the officers' quarters aft, is lined with lead on the inside, with the unusual precaution of having the outside protected by sheet-iron. There are three distinct modes of flooding this magazine, viz.: from the sea, by a powerful hand-pump, and by the donkey-engine pump. A small armory is arranged between the magazine and the cabin, containing thirty Spencer carbines, thirty Spencer pistols, and an equal number of cutlasses and dirks, the latter being accessible only from the cabin. In addition to the ordinary water tanks, a "fresh water maker" of ample capacity is provided, in which the condensation of the steam is effected by the current of sea-water which passes through the surface condenser; the fresh water being drawn off through a bent pipe on deck. A combined capstan and windlass of novel construction sufficiently low to fire over, is bolted to the deck over the chain locker at the bow; the combination being such that the capstan may be used alone, or one or both anchors raised at the same time. The quarters of the crew are arranged between the forward boiler, bulkhead, and the shell-room, which is situated under the bow-gun. Two large ventilators, with swinging tops, are applied for supplying the berth deck with fresh air. The shell-room is divided into several compartments provided with convenient shelves lined with zinc; separate lockers being arranged for storing ammunition for small arms. The shells are not, as customary in our Navy, contained in rude boxes strapped with iron. Each shell is placed in a well finished box provided with a sliding lid and rope handles, for convenient handling—a great improvement, as the shells may be taken out quickly and without being jarred. We will close our hasty description by mentioning that the wire

shrouds and smoke-pipe braces are provided with turnbuckles, by means of which, setting up and adjustment may be effected at any time by a single hand. Each gunboat is provided with two cutters and a yawl, all provided with a complete suit of masts, sails and awnings.

Respecting the armament the following brief notice must suffice for the present: It consists of a 100-pound rifle gun placed at the bow—a Parrott rifle—but a very different weapon from that represented by the photographed fragments which embellish so many pages of General Gillmore's famous book. Briefly, it is an improved Parrott 100-pound rifle with wrought-iron hoops round the chamber, carried to within 3 ins. of the trunnion; the chase being increased to correspond with the increased strength attained by the extension of the re-enforce. The severe ordeal through which the improved gun has passed during recent trials at Cold Spring conducted by the Spanish officers promises so well, that no doubt this improved Parrott gun has a future.

To Captain Ericsson's new gun-carriage, on which the improved gun is mounted, one of the leading features of the Spanish gunboats, we have space for only a cursory notice. It will be inferred from what has already been stated that the intention is to fire over the bow and in line with the keel. For this purpose and in order to command a wide horizontal range, a circular platform of wood, surrounded by a brass ring of 12 ft. 6 ins. diameter, is bolted to the deck at the bow. The gunslide, composed of wrought-iron, provided with friction rollers at both ends, rotates round a pivot secured to the deck, in the centre of the said brass ring. The carriage is made of light wrought-iron plates and angle iron riveted together in such a manner as to insure great strength longitudinally as well as transversely. By means of an eccentric movement, controlled by a suitable handle, the compressor which connects the carriage and the slide may be tightened or relieved so quickly that detachment will be quite safe during rolling; hence the gun may be run in and out by the vessel's motion alone. To admit of the gun firing in a direct line with the keel, the ordinary jib-stay has been abolished, and in place, two separate stays attached to the timber bulwarks, one on each quarter. Under canvas, a temporary jib-stay is secured to a shackle bolted to the outside of the stem. By these expedients the gun will have an uninterrupted horizontal range of 240 degs.

The gunboat which was first finished made two trips to West Point, in September, the result being deemed highly satisfactory. The official trial did not, however, take place until October 25th. But for the disadvantage of a combined river and tidal current, the Hudson above Fourteenth street would offer an unequalled trial ground, the river being perfectly straight and running exactly at right angles with the streets. The ground selected for the trial trip was from Fourteenth street to One Hundred-and-Twenty-ninth street, a distance of 30,720 ft., or 5.81 statute miles. The run up the river against the tide occupied 32 min. 35 sec., the return trip being performed in 29 min. 35 sec. Total distance 11.62 miles, in 62 min. 10 sec. Considering the small size and necessarily full lines of these gunboats, the speed thus attained is remarkable. In open water out of the tidal river current, which so injuriously affects the propeller by a difference of speed at the upper and lower circumference, a higher rate will undoubtedly be attained. It should be stated that the vessel, during the trial, was loaded with pig-iron to her intended maximum draught.

A fleet of 30 war-vessels, precisely alike, being by no means an ordinary sight, a visit to Delamater's Works on the Hudson, where the saucy-looking craft are now stationed, ten abreast, cannot fail to be very interesting to naval men. It is a significant fact that this great display of offensive and defensive force is the result of the efforts of a single establishment, directed by individual skill. Evidence more conclusive could not be furnished, that the progress of the country and its resources are equal to any future emergency.

A VEIN of excellent coal has been discovered, extending along the line of the Kansas Pacific Railroad, east of Denver. This discovery shows that the workable coal beds of the Rocky Mountains extend miles eastward into the great plains, and is of the greatest importance both to settlers and to the railway company.

ON THE OUTFLOW OF STEAM.

By J. W. MACQUORN RANKINE, C. E., LL.D., F. R. S.

From "The Engineer."

1. Having been led, by careful consideration of Mr. R. D. Napier's researches on the outflow of steam, to the conclusion that the fundamental principle of his theory is substantially correct, I propose to show, in this communication, how that principle is to be used in combination with the expressions for the energy developed by expanding steam, which are deduced from the laws of thermodynamics.

2. In the first place, I will refer to the thermodynamic formula for the velocity of outflow of a perfect gas. If that formula is to be named after its first publisher, it should, so far as I know, be called "Weisbach's formula," and by that name I will denote it for brevity's sake throughout this communication.

It is quite true, as Mr. R. D. Napier has pointed out, that the ordinary method of using Weisbach's formula is based on the supposition that the pressure at the contracted vein or throat of the jet is the same as in the space into which the gas is discharged. That this supposition is realized in the case of air (and probably of other gases) issuing from a conoidal converging nozzle of the form of the contracted vein, with pressures in the air vessel ranging up to about double the external pressure, is proved by the experiments of Weisbach, in which the quantities discharged from such a nozzle agree practically with those given by the formula. But if by any means, such as the addition of a trumpet-shaped expanding discharge pipe to the nozzle, the pressure at the contracted vein were made to become different from that in the outer space, or if the jet were to spread of itself after issuing from the orifice, and if the pressure were not to become equal to the outside pressure until the sectional area of the jet had become greater than that of the throat, it is evident that results very different from those commonly deduced from the formula would be obtained. The formula, however, might be made applicable to such cases, supposing friction to be insensible, by taking for the effective area of outlet, not that of the throat of the nozzle, but the transverse area of the jet at the place where its pressure first becomes equal to that in the outer space.

3. In the experiments of Weisbach the outside pressure, being always that of the atmosphere, was not varied to any material extent; and therefore the circumstances were not adapted to show directly the existence of a maximum in the *mass* discharged with a constant inside pressure and a variable outside pressure. The only experiments I knew of which directly show such a maximum are those of Thomson and Joule. Of course there can be no such intermediate outside pressure corresponding to a maximum in the *velocity* of discharge, which must increase with every diminution of the outside pressure; although there is a limit to the increase of that velocity when the outside pressure becomes inappreciably small.

4. It appears from Weisbach's experiments that, in order that the formula may give correct results with a constant coefficient of discharge, it is necessary that the nozzle should in every case have an entrance resembling the contracted vein. For example, in the following cases the co-efficients of discharge may be considered as practically constant.

Coefficient of discharge:—Conoidal nozzle of the form of the contracted vein, from 0.97 to 0.99. Short cylindrical tube, bell-mouthed at the inner end, from 0.92 to 0.93.

On the other hand, when the entrance to the nozzle is sharp-cornered, or when the outlet is simply a hole in a thin plate, the coefficients of discharge are irregular.

5. *General Formulæ for the Outflow of Elastic Fluids.*—The following formulæ for the outflow of elastic fluids have long been well known. Let p_1 be the absolute pressure inside a vessel, such as a boiler, and p_2 the absolute pressure outside. Let U denote the work done by an unit of weight of the fluid employed, if admitted into a cylinder at the pressure p_1, expanded till the pressure falls to p_2, and expelled at the latter pressure. Then the final velocity with which the fluid will

escape from an outlet in that vessel will be given by the following formula :—

$$v = \sqrt{(2\,g\,U)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

g denoting gravity.

Let s_2 be the volume of the space occupied by unity of weight of the fluid in the escaping jet at the instant when its pressure becomes equal to the external pressure p_2 ; then the weight of fluid which escapes per second through each unit of *effective area* of outlet is expressed as follows :—

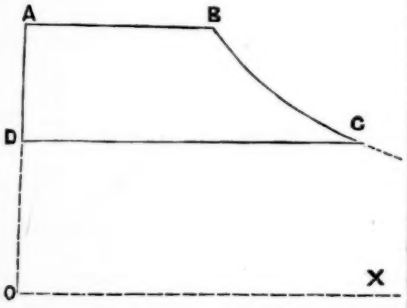
$$m = \frac{v}{s_2} = \sqrt{\frac{(2\,g\,U)}{s_2}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

I will call this for brevity's sake the *mass-velocity.*

6. The general formula for the quantity of work U, in all cases whatsoever, is as follows :

$$U = \int_{p_2}^{p_1} s\,dp \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where s is the volume occupied by unity of weight of the fluid when its pressure is p. The quantity of work U may be represented by the area of a diagram such as A B C D ; where A B represents



s_1, the initial volume, and D C represents s_2, the final volume, of unity of weight ; D A represents $p_1 - p_2$, the total fall of pressure ; and B C is the expansion curve. The zero line of absolute pressure is represented by O X. It is evident that the mass-velocity

$$m = \sqrt{\frac{2\,g\,U}{s_2}} = \sqrt{\frac{2\,g}{D\,C}} \cdot \sqrt{(A\,B\,C\,D)}$$

varies proportionally to the square root of the ratio which the area A B C D bears to a square described on D C as a base, which ratio is equal to the ratio that the mean height of the line A B C above D C (which mean height represents the mean effective pressure) bears to D C. This mode of viewing the matter makes it easy to understand how it is that for a given inside pressure there is a certain outside pressure which makes the mass-velocity a maximum. For, on the one hand, when D C is very near to A B, the rate in question becomes very small through the smallness of the effective pressure ; and, on the other hand, when D C is very near to O X the same ratio becomes again very small through the great increase of D C ; so that the greatest value of that ratio must be given by some intermediate position of D C ; and this holds for every known law of expansion. The way in which the volume s varies with the pressure p depends on the nature and condition of the fluid, and the circumstances in which it is placed as to transfer of heat.

Although the pressure denoted by p_2 in the preceding formulæ is equal to that in the outside space, the corresponding volume of unity of weight of the fluid in the jet s_2 is *less* than the volume ultimately assumed by the same mass when it comes to a state of rest ; for the extinction by friction of the motion of the jet causes the temperature of the quiescent external fluid to be higher than that of the escaping jet.

When steam which, though saturated, is *dry inside the boiler,* escapes through an outlet, the exact formulæ for the mass-velocity under different circumstances as to transfer of heat, and the approximate formulæ, which may be substituted for those exact formulæ, give results whose differences from each other are not of much importance in a purely practical point of view. But when the steam within the boiler is misty, and holds liquid water in suspension, the results may differ very widely from those for dry steam. In any case, it may be instructive to compare together the several formulæ, exact and approximate, for the work U and the volume s_2 under different circumstances.

7. *Steam Gas.*—For steam superheated to such an extent as to be sensibly in the perfectly gaseous state, both before and during its expansion, if it escapes without receiving or giving out heat, the proper formula is that of Weisbach, already referred to, with the value 1.3 for the index of the power of the density to which the pressure is proportional. Examples of

the results of this formula, calculated by Mr. Baldwin, have already been given in "The Engineer."

8. *Saturated Steam, with a Non-Conducting Nozzle.*—The exact thermodynamic formula for the quantity of work denoted by U, when steam free from moisture expands without transfer of heat, was independently investigated by Clausius and myself, and published by me in a paper read to the Royal Society in 1853, and printed in the "Philosophical Transactions" for 1854, and by him in lectures delivered orally in 1854, and in a paper in "Poggendorff's Annalen" for 1856. It is as follows :

$$U = J \left\{ t_1 - t_2 - t_2 \text{ hyp. log. } \frac{t_1}{t_2} \right\} + \frac{t_1 - t_2}{t_1} H_1 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In which J denotes Joule's dynamical equivalent of a degree of heat in liquid water, being 772 ft. per degree Fahr., or 424 metres per degree Centigrade ; t_1 and t_2 are the absolute temperatures corresponding to the pressures of saturation p_1 and p_2 respectively ; and H_1 is the dynamical equivalent of the latent heat of evaporation of an unit of weight of water at the higher pressure. The value of H_1 is given to a close approximation by the formula

$$H_1 = a - b\, t_1 \quad . \quad . \quad . \quad . \quad . \quad (4A)$$

in which a=1,109,550 ft., or 338,191 metres ; and b=540 ft. per degree of Fahr., or 297 metres per Centigrade degree ; and thus the value of U is made to depend on the two temperatures t_1 and t_2 alone.

The steam partially condenses during the expansion ; and the liquid water thus formed is re-evaporated through the heat produced when the motion of the jet is extinguished by friction. The volume s_2 to be used in calculating the mass-velocity is that of the moist steam at the end of the expansion, and its value is as follows :

$$s_2 = \frac{d\, t_2}{d\, p_2} \left(J \text{ hyp. log. } \frac{t_1}{t_2} + \frac{H_1}{t_1} \right) \quad . \quad . \quad . \quad (5)$$

in which $\frac{d\, t_2}{d\, p_2}$ denotes the rate of variation of temperature with pressure of saturation at the lower limit of pressure.

By comparing the volume s_2 given by the formula, with the volume of unity of weight of dry saturated steam at the pressure p_2, the proportion of steam temporarily liquefied may be calculated.

The equations 4 and 5 were originally demonstrated with a view to their employment in calculating the work of steam in steam-engines. Zeuner was the first (so far as I know) to apply them to the question of the outflow of steam, which he did in a paper entitled "Ueber den Ausfluss von Daempfen und hocherhitzten Fluessigkeiten aus Gefaessmuendungen," published in the "Civilingenieur" for 1864, vol. x. part 2. The following are examples of results calculated by him. The mass-velocities of outflow are given in kilogrammes per second per square metre of effective area of outlet; and I have added the corresponding values in pounds per second per square inch of effective area. The external pressure in each case is that of the atmosphere.

Internal absolute pressure, Atmosph's	Velocity. Metres per second.	Mass-velocity. Kilogs. per sq. metre per second.	Mass-velocity. Pounds per sq. inch per second.
1	0	0	0
2	481.72	304 83	0.434
3	606.62	393.15	0 559
4	681.56	449.28	0.639
5	734.42	490.53	0.698
6	775.00	523.22	0.744
7	807.85	550.12	0.783
8	835.00	573.25	0.815
9	858.41	593.89	0.845
10	878.92	611.16	0.869
11	896.87	627.18	0.892
12	913.05	641.73	0.911

Within the limits of pressure that are usual in practice, the density of originally dry saturated steam when expanding in a non-conducting cylinder varies nearly as the ninth power of the tenth root of the absolute pressure, and therefore the following approximate formulæ may be used instead of equations 4 and 5 :

$$U = 10\, p_1\, v_1 \left\{ 1 - \left(\frac{p_2}{p_1} \right)^{\frac{1}{10}} \right\} \quad . \quad . \quad (6)$$

$$s_2 = s_1 \left(\frac{p_1}{p_2} \right)^{\frac{9}{10}} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

9. *Outflow of Superheated Water.*—The following expressions for work done in driving a piston in a non-conducting cylinder by an unit of weight of water admitted into the cylinder while wholly in the liquid state, and for the volume to which that water ultimately expands by

partial evaporation, were investigated independently by Clausius and myself, and first published in the two papers already referred to.

$$U' = J\left\{t_1 - t_2\left(1 + \text{hyp. log. } \frac{t_1}{t_2}\right)\right\}[+l(p_1 - p_2)] \quad (8)$$

$$s'_2 = \frac{d\ t_2}{d\ p_2}\left(J \text{ hyp. log.} \frac{t_1}{t_2} = \frac{H_1}{t_1}\right)[+l] \quad . \quad (9)$$

in which l denotes the volume of unity of weight of liquid water, and the other symbols have the meanings already explained in article 8.

In my own application of these formulæ the terms enclosed in square brackets [ ], which depend on the volume l of the water when in the liquid state, are neglected, as being practically inappreciable. In Zeuner's calculations those terms are taken into account for the sake of greater precision. In fact, the terms in square brackets ought to be inserted in the equations 4 and 5, in order to give absolute precision.

The formulæ 8 and 9 (subject to the preceding explanations) were applied to the outflow of superheated water from a boiler by myself in the "Philosophical Magazine" for December, 1863, and by Zeuner in the paper already referred to, published in the "Civilingenieur" for 1864. The results of the calculations of both authors give for the mass-velocity of superheated water escaping into the atmosphere from a boiler in which the internal absolute pressure ranges from two to twelve atmospheres, values differing little from 1120 kilogrammes per second per square metre of effective area, or very nearly 1.6 lbs. per second per square inch of effective area.

10. *Outflow of Mixed Water and Steam.* —Clausius was the first to combine the expressions 4 and 5 with the expressions 8 and 9, so as to obtain the values of the work done in a non-conducting cylinder, and of the final volume assumed, by a mixture of steam and liquid water in given proportions. In each unit of weight of the mixture let f be the fraction that is in the liquid state, and $1-f$ the fraction that is in the vaporous state at the beginning of the expansion. Calculate U and s_2 as for steam, by equations 4 and 5, and U' and s'_2 as for superheated water, by equations 8 and 9; then the mass-velocity is

$$m = \sqrt{\frac{2g}{(1-f)s_2 + f\,s'_2}\{(1-f)\,U + f\,U'\}} \quad . \quad (10)$$

11. *Outflow of Saturated Steam kept dry.* —If we suppose the steam to escape through a conducting nozzle, from which it receives just heat enough to prevent any liquefaction, the value to be taken for U is that of the work done by an unit of weight of dry saturated steam in a jacketed cylinder. The only original investigation of the exact value of that quantity of work, with which I am acquainted, is that contained in a paper of mine which was received by the Royal Society in December, 1858, and printed in the "Philosophical Transactions" for 1859, page 177. The formula is as follows :—

$$U = a \text{ hyp. log. } \frac{t_1}{t_2} - b\ (t_1 - t_2) \quad . \quad . \quad . \quad (11)$$

in which t_1 and t_2 are, as before, the absolute temperatures corresponding to the inside and outside pressure respectively; and a and b are the coefficients already given in the formula for the latent heat of steam; viz., a = 110955 ft. = 338191 metres; b = 540 ft. per degree of Fahr., or 297 metres per Centigrade degree.

The value of s_2 is simply the volume of unity of weight of dry saturated steam at the pressure p_2, that is to say

$$s_2 = \frac{d\ t_2}{d\ p_2}\left(\frac{a}{t_2} = -b\right) \quad . \quad . \quad . \quad . \quad (12)$$

Tables and diagrams have been published, from which the values of U and of s_2 can easily be found.

In the paper just cited it was shown that within the limits of pressure which are usual in practice, the density of dry saturated steam varies nearly as the sixteenth power of the seventeenth root of the absolute pressure; hence the following approximate formulæ may be used:—

$$U = 17\,p_1\,v_1\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{1}{17}}\right\} \quad . \quad . \quad . \quad (13)$$

$$s_2 = s_1\left(\frac{p_1}{p_2}\right)^{\frac{16}{17}} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

12. *Mr. R. D. Napier's first Formula* gives results whose differences from those of Zeuner's calculations are immaterial in practice so long as the internal absolute pressure does not exceed twice the external absolute pressure. It has been shown by Weisbach (Civilingenieur, 1856) that a formula resembling that of Mr. Napier, though not quite identical with it, gives a value of the velocity of outflow of air about $2\frac{1}{2}$ per cent. greater than that given by the exact thermodynamic formula when the external pressure is twice the external

pressure. It is obvious that the simplicity of Mr. Napier's formula is a great advantage in calculations for practical purposes.

13. *Effective Area of Outlet.*—When the external pressure does not exceed about twice the internal pressure, it appears, from the experiments of Weisbach on air, and of Mr. R. D. Napier on steam, that the effective area of outlet is sensibly that of the contracted vein or throat; that is, for a tapering conoidal nozzle, an area very little less than that of the narrow end of the nozzle, and for a short cylindrical tube from .9 to .8 of the transverse area of the tube, according as the entrance to it is rounded or not at the inner end.

Zeuner, near the end of the paper already referred to, considers it probable that the effective area of the jet is in general *greater* than the actual transverse area of its throat or narrowest part, in a proportion depending partly on the form of the outlet and partly on the pressure. He makes no attempt to determine from theoretical principles what laws that proportion may follow, and states that those laws are to be ascertained by experiment only.

The experiments of Mr. R. D. Napier are to be considered as forming an important step towards the determination of those laws. The following table shows some examples of the calculation of the ratio of the effective area of the jet to that of its throat, or *coefficient of extension*, as it may be called, based on a comparison of the results of Mr. Napier's *second* formula (regarded as representing his experiments empirically) and those of Zeuner's calculations already referred to.

External pressure, 1 atmosphere.		
Internal pressure, atmospheres,		
2	3	4.
Mass-velocity in kilos. per square metre per second (Zeuner),		
304	393	449.
Discharge in kilogrammes per second per square metre of throat of jet (Napier),		
316	478	632.
Co-efficient of extension,		
1.04.	1.22.	1.41

Experiments on the outflow of steam should be made with nozzles of the form of the contracted vein, opening at once into large receivers, or into the atmosphere ; for thus are obtained values of the coefficient of extension when freed from the effects of special forms of outlet. That the effects of such forms may be very great will at once appear when it is considered that in an outlet having a conoidal converging part at the inner end, a narrow throat, and a gradually diverging trumpet-shaped part at the outer end, the effective area (subject to certain limitations which it is unnecessary here to state in detail) is well known to be situated, not at the narrow throat, but at or near the wide mouth. This, in fact, is one of the essential principles of the action of jet pumps, injectors, and ejectors. Even when the widening towards the mouth takes place abruptly, as when a narrow cylindrical tube is followed by a wide one, the effective area is not that of the narrow tube, but is intermediate between the area of the narrow tube and that of the wide tube. Such appears to have been the construction of the apparatus employed by Mr. Napier in an experiment described in his letter which appeared in "The Engineer" of the 1st of October, 1869. The mass-velocity, calculated theoretically from the pressures, is about 22 lbs. per minute per square inch of effective area ; the discharge per minute was 13 lbs.; therefore the effective area was about 0.6 of a square inch. The transverse area of the narrow pipe was 0.246 of a square inch ; that of the wider pipe, between 0.785 and 1.23 square inch. Hence it appears that the effective area of the jet was intermediate between those of the throat and of the mouth of the outlet tube.

14. *Maximum Mass-Velocity.*—Mr. Napier's second formula may be regarded as approximating to the results of the supposition, that when the outside pressure falls below that which corresponds to the maximum mass-velocity, the coefficient of extension adjusts itself in such a way that the pressure corresponding to the maximum mass-velocity is still maintained at the throat of the jet ; a supposition not improbable in itself, and confirmed, at all events approximately, by Mr. Napier's experiments so far as they have gone.

In order to determine the consequences to which this theory leads when applied to the more exact formulæ for the work done by steam in expanding, it is to be observed that if the absolute pressure varies nearly in proportion to that power

of the density whose index is n, the greatest mass-velocity is attained when the pressure at the throat, or narrowest part of the outlet, bears the ratio to the internal pressure which is expressed by the following fraction :

$$\left(\frac{n+1}{2}\right)^{\frac{-n}{n-1}}$$

The following are examples of the value of that fraction :

$n=$	1	$\frac{1}{1.6}$	$1\frac{1}{3}$	1.3	0.408
$\left(\frac{n+1}{2}\right)^{\frac{-n}{n-1}}=$	$\frac{2}{3}$	0.5968	0.5823	0.5457	0.5269

The last of these values approximates nearly to $\frac{1}{2}$, being the value assumed by Mr. Napier.

It has already been stated that when dry saturated steam is supplied during its expansion with heat just sufficient to prevent liquefaction, the value of n is $\frac{1}{1.6}$ nearly; hence the absolute pressure in the throat of the outlet corresponding to the greatest mass-velocity is very nearly 0.6 of the absolute internal pressure. The following table shows some examples of maximum mass-velocities calculated according to those principles, expressed in *pounds per square inch of throat of outlet per second;* and compared, first, with the results of Mr. Napier's second formula as shown by his Table, and, secondly, with those of a formula found by trial, and which, although it gives a very rough approximation, is convenient because of its great simplicity; it consists in taking *one-seventieth part of the absolute internal pressure on a given area* for the mass discharged through an equal area of throat.

Temperature, Fahrenheit	Absolute internal pressure—lbs. on the square inch.	Maximum mass-velocity—lbs. per sq. inch of throat per second.		
		Theoretical formula.	Mr. R. D. Napier's formula.	Rough formula.
212	14.70	0.219	0.232	0.210
239	24.54	0.360	0 372	0.351
248	28.83	0 415	0.440	0.412
293	60 40	0.860	0.901	0.863
329	101.9	1.433	1.490	1.456
356	145.8	2.025	2.185	2.083
419	305.5	4.144	4.700	4.364

The fourth of these examples, in which the absolute internal pressure is 60.4 lbs. on the square inch., and the theoretical mass-velocity per square inch. of throat is 0.86 lbs. per second, or 51.6 lbs. per minute, agrees very closely with Mr. Napier's experiment described in "The Engineer" of the 1st Oct., 1869, p. 228, col. 2.

15. *Conclusions.*—From the general agreement of the results of Mr. R. D. Napier's formulæ with those of his experiments, and of both with those of theoretical formulæ taken in combination with the supposition that the pressure at the throat of the outlet never falls below that corresponding to the maximum mass-velocity, it may be inferred that the following conclusions, if not absolutely proved, are at all events highly probable.

First. The pressure at the throat of the outlet never falls below that corresponding to the maximum mass-velocity of outflow, how low soever the external pressure may be; and, so far as I know, the merit of originally proposing and applying this principle belongs to Mr. R. D. Napier.

Secondly. A rule based on the combination of the preceding principle with thermodynamic formulæ and tables for the work of expanding steam, gives results nearly agreeing with those of Mr. Napier's experiments and of his second formula.

Thirdly. Mr. Napier's pair of formulæ give results which are good approximations for practical purposes.

Fourthly. As a rough approximation, the weight of steam discharged through a given area of *throat* may be taken as nearly equal to *one-seventieth* part of the internal absolute pressure on an equal area, when that pressure is not less than five-thirds of the external absolute pressure. When the internal absolute pressure is less than five-thirds of the external absolute pressure, calculate the outflow as if for an internal absolute pressure equal to five-thirds of the external pressure, and diminish it in a proportion expressed by the square root of the ratio, in which the actual difference of pressures is less than two-thirds of the external absolute pressure.

These rough rules are expressed in symbols as follows: Outflow in units of weight per unit area of throat, nearly when:

$$p_1 = \text{or} > \tfrac{5}{3}\, p_2 ;$$
$$\text{outflow} = p_1 \div 70 ;$$
$$\text{and when } p_1 > \tfrac{5}{3}\, p_2 ;$$
$$\text{outflow} = \frac{p_2}{42} \cdot \sqrt{\left\{\frac{3\,(p_1 - p_2)}{2\,p_2}\right\}}$$

THE PROPERTIES OF MALLEABLE CAST-IRON.

By DR. ADOLPH OTT.

From the "Journal of Applied Chemistry"

The increased flexibility of malleable iron, according to Mr. R. Mallet, is to be attributed to the fact that small crystalline scales of graphite are uniformly disseminated through the mass of the iron. Indeed it is otherwise known that the most rigid materials become flexible when fibrous or scaly crystals of different natures are distributed through them; these latter may themselves form in flexible bodies when united to larger masses. The flexible Indian sandstone, for instance, consists of a mass of quartz crystals through which fibres of asbestos are uniformly disseminated; other kinds of flexible sandstones contain mica crystals in the quartz mass, as, for instance, the itacolumite, which, in Brazil, is regularly associated with the diamond. The flexibility of the respective bodies must in all these cases be ascribed to the property of the smooth crystals to change their relative position to each other, and, with regard to the mica scales in the sandstone, they behave like the graphite scales in the iron.

According to Pelouze and Fremy the specific gravity of malleable iron approaches very nearly that of cast-iron. Brull, as the result of three determinations, found the numbers 7.10, 7.25, and 7.35. The specific gravity of wrought-iron being from 7.6 to 7.8, we have another proof that malleable cast-iron is not identical with wrought-iron. The fracture of malleable cast-iron is very different from that of any kind of wrought-iron; it is darker and less brilliant, and lacks that fibrous aspect so characteristic of tough wrought-iron. It is similar to dark and ordinary pottery, but different from it in color and lustre. In forging, the aspect of the fracture becomes greatly altered, on account of the flexibility of the material, which sometimes requires considerable hammering before it breaks. The fracture of very carefully manufactured malleable iron appears on the average more like that of a very fine-grained, white cast-iron than that of wrought iron. In large pieces the fracture is uniform throughout. In filing, turning, and planing it works quite similar to wrought-iron, but the surface often appears somewhat whiter. Large pieces can seldom be well turned to a great depth. According to some statements, malleable iron is capable of taking a better polish than cast-iron, and it takes as good a one as cast-steel. It also holds a better lustre than many sorts of dark and impure wrought-iron, but the polish is inferior to that of good steel, as in razors of first quality, even the surface appears a little whiter. Good hard cast-iron may probably be polished as well. With regard to the hardness, reliable data are not procurable. Malleable cast-iron is generally very soft—softer than wrought-iron of any kind. It takes the impression of the hammer with a very slight blow, and wears off rapidly in contact with rough surfaces.

It is exceedingly porous, as may be expected from its small density. According to Brull, oil, when left in a cup of malleable iron, penetrates through it in a very short time; the correctness of this assertion, however, remains doubtful. Cast-iron bells are far more elastic than bells of malleable iron, producing also a higher and clearer sound.

Morin and Tresca have found that the elasticity of malleable cast-iron is considerably less than that of the most inferior wrought-iron. The absolute power of resistance is indicated by the latter as being thirty-five kilogrammes per square metre. Thin pieces, of a diameter not over one-quarter or three-eighths of an inch, may be bent while cold, without cracking; but they can rarely be restored to their original state without being partly or altogether fractured. However, the end of a rod may be forged till red hot, without a break or crack being produced; thin plates may safely be hammered into hollows, provided they are not too deep. Malleable iron will bear rolling to a small degree. All these manipulations bring about a closer grain, and a fracture similar to that of fine-grained steel-like iron. No instance is known where malleable iron has been drawn into wire; but this is possible, since it will bear a slight elongation, assuming thereby a finer grain. It may be pretty well forged at a low red heat, somewhat

above a cherry-red heat, but in endeavoring to beat it out, it tears and breaks to pieces. According to Mallet, this temperature, and that beneath a bright yellow heat, are those at which it may be best forged; but it is more than probable that various kinds act differently under the same circumstances. This peculiarity certainly deserves further attention, on account of the fact that various articles which have not, as yet, been produced from malleable iron, might advantageously be made from it in cases where the form of the cast piece might have to be altered afterward. When hammered at yellow heat, malleable iron falls to pieces, and large, not uniformly cemented pieces, appear in the interior.

It is clear that malleable iron cannot be welded properly; indeed, this is the case even if two pieces can be made to stick together, and the surface of contact be kept free from rust; it is self-evident that it cannot be welded with wrought-iron or steel, still it may be soldered with them by means of hard solder. With respect to the fusing point of this metal, it is a high one; it lays above that of gray or halved cast-iron, but probably not above that of many sorts of white or hard cast-iron, and certainly considerably below that of cast-steel. In the fire, malleable cast-iron is said to become more slowly oxidized than ordinary cast-iron. In France, the silver refiners use a large number of crucibles that are manufactured from that material, but no accounts exist of how much iron they leave to the silver. According to Brull, malleable iron can be tempered with the ordinary carboniferous cementing powders, as well as with prussiate of potassa. If watered when bright red hot, it may be tempered more or less; still the temper is always imperfect, not uniform, and quite different from that of good steel, but perhaps more perfect than that which wrought-iron assumes, when suddenly cooled. Still, correct statements are yet wanting with regard to this point.

REPAIRED BOILERS.

From "The Engineer,"

The dangerous character of steam boilers which have been subjected to repeated mending is notorious to every engineer who has given even the slightest attention to the working of this class of machinery. His list of boiler calamities will contain many conspicuous records of serious disasters resulting from the incapability of many people who have had the practical oversight of boilers at ironworks, and collieries in particular, to detect when a boiler has been sufficiently patched. Those records will likewise strengthen him in his conviction that very many workmen to whom repairs are intrusted are altogether unfit for their duties.

There is hardly any operation connected with the repair of a boiler more productive of danger than that by which rivets are brought into a line. The day is gone by, we hope, when in new boilers the longitudinal seams are made to run in a continuous line from end to end, with the transverse seams also continued completely round the boiler, giving at the corner of each plate four thicknesses of iron. Yet unskilful repairs often produce continuous lines of rivets at the very place in a boiler where it is most desirable that there should be the brick-wall-like arrangement of the seams, which adds much to the strength, and also often prevents a rent from continuing forward to a dangerous point. A large externally fired tube boiler at an ironworks in Wolverhampton some time ago burst its shell. The first rupture took place in a seam over the fire, where frequent repairs had led to a considerable length of longitudinal seam, being in one continuous line. The four plates over the fire parted and opened out until they had ripped two seams completely round the boiler. The plates were thrown in one flat piece upon a bank behind, whilst the main body of the boiler, with the tubes, was turned over and the front end blown away. More recently, at Newcastle-upon-Tyne, a plain cylindrical boiler was much torn up, and all the fragments thrown to the front of their original position. The boiler was very old and much deteriorated, so that it was unable to bear the ordinary pressure, a longitudinal arrangement of the

plates contributing to the weakness. Shortly afterwards, in the same town, a similar boiler was much torn and scattered. Here, too, the plates had been arranged longitudinally, and the accident began at a patch lately put on. The boiler had become so deteriorated by nearly thirty years' wear, that it was not able to do the moderate duty required of it. Very quickly afterwards, at Durham, another plain cylinder, with plates longitudinally arranged, and which had been working twenty-seven years, gave way at an old fracture over the grate, and was torn into four pieces, which fell a great distance off; and on the 18th of October last a plain cylinder with round ends, 40 ft. long and 6 ft. diameter, made of half-inch plates, and set with a fire-grate at one end, and flash flue, exploded at the works of the Great Bridge Iron and Steel Company, in South Staffordshire. The front end, with three rings of plates, was thrown up to a sufficient height to clear the buildings, and fell into a pool some distance to the right and slightly to the rear, the remaining part of the boiler being left near to its original position. The boilers on each side were thrown off their seats, that on the left knocking down a new upright boiler which was nearly ready to work. The first rent appears to have taken place at a seam over the left side of the fire-grate, where four new plates and a long patch had been inserted. This rent must have instantly extended across the front of the man-lid above and around the fourth transverse seam, near some patches, thus allowing the shell to open out, the reaction of the issuing contents sending the fragments upwards. There were so many patches in the boiler, especially around the part which gave way, that many seams were made in continuous lines without any break of joint, and a great number of rivets must have been removed from some of the seams more than once, thereby very much reducing their strength. "I believe," said Mr. E. B. Marten, from whose evidence at the inquest last Friday we have been quoting, "the cause of the explosion was simply that this frequent repair had so reduced the strength of the boiler that it was unable to bear even the usual working pressure. It is often difficult," he adds, "to convince those who have the repair of boilers that the putting of patch upon patch reduces the strength of the boiler, until it is completely untrustworthy, although it may not leak; but several explosions this year, and very many in past years, have proved the fact beyond dispute. The great havoc caused by such an explosion as that now under investigation, leads many casual observers to suppose that they are caused by some sudden accession of force within the boiler; but the enormous force pent up within any high-pressure boiler is quite sufficient to account for all the mischief, when the balance of strain in the fabric is destroyed by the sudden giving way of a weak seam."

It is as true now as it was eighteen hundred years ago that an effectual way of destroying that which is old, is to patch it with that which is new. The danger is more in the patching than in the repairing. True, a boiler, any more than a garment, is not as strong after repair as when new, even though not a patch, but a new breadth be inserted; still the new breadth, properly put in, is much less likely to bring about destruction than the patch. Very little capital, and hardly more ability, is needed in the coal and iron districts to enable a man to pass muster as a "boiler maker." He should rather be termed a boiler mender. A portable forge, a few hammers and drifts, and he is set up. Small colliery proprietors, and sometimes iron-works-people, instead of sending for help to a boiler-making firm of standing, too often call in these small masters. When an accident happens, the evidence of empirics of this class is too often gravely taken as the evidence of "practical" men. Invariably the proprietor of the boiler is able to say that he has given orders for everything to be done to the boiler maker considered necessary. The boiler mender, knowing that, because of its lesser first cost, a patch would be far more in consonance with the proprietor's views than a whole plate, had patched, and not effectually repaired, the boiler; and he is always ready to declare to a coroner and jury that, in his opinion, all had been done that was necessary. Yet how frequently it turns out that the accident has happened almost immediately after the repairs have been done. In the case of a cylinder boiler at Dudley, not long since, this frequent patching over the fire had brought the longitudinal seams for several plates without break of joint. A patch had been

put on a few days before the explosion, and as the rivet holes had badly fitted, there had been much strain caused by drifting, and the rivets were much distorted. The frequent and badly executed repairs over the fire-place had so weakened the structure as to make it unable to bear the very high ordinary pressure. In the case at Great Bridge, which has called forth this article, the boiler maker had only at 4 o'clock finished putting in some 16 rivets over the fire to stop a leakage, and at 7½, half an hour after steam had been got up in it, the explosion occurred, killing three people. In this case the boiler maker acted up to the light which he promised, and the proprietors of the boiler had no reason to believe that it was not as much light as was needed. His evidence is, that when called in he found the boiler in good repair, with the exception of a few rivets over the fire, which were leaking. How should it be otherwise than in good repair, for during the past two years he had frequently mended it over the part where the fire was placed? He had never any idea that the boiler was rendered unsafe in consequence of these frequent repairs; and their instructions always were to do all repairs required. This man had no notion that the patching, in the manner in which it had been performed in this case, was the chief immediate cause of mischief. Mr. Marten, however, testifies—as every other competent engineer would have testified under similar circumstances—that "the rivets, which were put into the boiler in the very line of the seam where they gave way, had proved the great point of weakness. Immediately that the fire was put under, and the steam got up, the openings extended from rivet hole to rivet hole, and the boiler exploded."

A very practical view suggested itself to one of the jurors. If the putting of patch upon patch had reduced the strength of the boiler till it had become completely untrustworthy, although it might not leak, "some one ought to know whether it was worn out." Mr. Marten responded that "the experience of engineers, who saw so many cases of this kind, was that, though boilers in such a condition as the one in question might last for many years, sometimes they burst at once after being repaired. The question was, whether those who saw a boiler thought it was safe or not." One of the manager of the works, it transpired, who had been there 8 years, had never had any reason to believe it was unsafe; the boiler maker believed it safe; and the engine-tender, who had charge of the 6 boilers at the works, believed the same—indeed, did not see that it leaked until his son pointed out that defect. At the testimony of these workpeople no reader of "The Engineer" will be surprised. But the evidence of the secretary of the company was that all the boilers used by the company were insured with the Manchester Boiler Insurance and Steam Power Company, whose agents were accustomed to visit the works once in 6 months. On the 6th of October an external examination was made on behalf of the Manchester Company. "From that inspection he was led to believe that the boilers were in good condition." In May last the agent of the Boiler Company made an internal inspection, and suggested certain repairs, which it was not disputed were carried out. The secretary added, in reply to the coroner, that in May nothing was said as to the boiler being unfit for use, "or they should have condemned it." Yet, to replace this very exploded boiler, and also "any other which most required to be replaced," orders had been given for two new boilers. One of these Mr. Marten speaks of above. Even a Black Country juryman, when this last fact came out, wanted to know why, if the boiler was safe, it was to be replaced? The reply he obtained was, that "boilers, when they got to a certain point, might be considered safe, and yet want replacing."

The moral of all this must be tolerably patent to the reader. (1) When boilers need repairs, those repairs should be put into the hands of boiler-making firms who have a reputation to sustain. (2) The surest way to ascertain the true condition of a boiler is to examine it at frequent intervals in every part, both inside and outside. (3) When, as in this case, such intimation has been conveyed to proprietors—whether by boiler insurance agents or others—that the time has come when a boiler should be replaced, it is the truest economy to lay it off at once. (4) It cannot be too strongly urged upon users of steam power that it is far safer and cheaper to renew a boiler than to resort to continual, expensive, and unsatisfactory patching.

RAILWAYS IN RUSSIA.

From "The Engineer."

The following is a translation of an article on the construction of railways in Russia, from the "Russian Railway Gazette:"

Railway construction is a business which may be said to be novel, not only in our own country, but in Western Europe, where it originated. This particular kind of communication, entirely differing from all methods of locomotion that had hitherto preceded it, owing to the ardor with which it was prosecuted at the first onset, we admit must necessarily have been liable to all kinds of errors and perplexities at the beginning, owing, more particularly, to the circumscribed nature of the human intellect in not being able to conceive at once an object in all its bearings. Having found out the means of conveying passengers and guards expeditiously, punctually, and cheaply, from one point to another, all promoters of railway schemes seem to have considered their duties and obligations finally accomplished, and in laying down rails between the towns, have left the rest to the personal means and the desire of private individuals, in no way caring, not only for the convenience of passengers and senders of goods, but even for that which forms their most essential requirements. Instances of this kind can easily be adduced; it will be sufficient to point out this alone, and in the northern countries the warming of the railway carriages has not been introduced, and ventilation neglected, so that passengers particularly on long distances, are subject to all the evils connected with severe winters and vitiated atmospheres. But all these are still minor defects, offered by our railroads, in comparison with those which we shall endeavor to point out in the present article. We will not allude to sleeping cars, which are looked upon by many as an unpardonable luxury and indulgence.* Railways having effected a more accelerated and cheaper communication between the towns, have naturally conferred a greater boon upon the public; but, at the same time, the promoters, carried away, as it would seem, by the supposed magnitude of these benefits, have studied only too superficially, other circumstances, which they have deemed details beneath their notice. Having deprived the public of their former mode of travelling on common roads, the constructors of railways should have well studied the nature of all the salient points connected with this substitute for the former mode of locomotion, which latter, certainly, notwithstanding its slowness and dearness, had its good points. These good points consisted in this, that the driver of a vehicle conveyed the passenger from the place of starting to the place of destination; the same was done by the carrier of goods; whereas, with our railways, all this takes place very often between the towns, and the passengers and goods are landed in the open country, miles and miles away from their destination. Secondly, in this, that the passengers enjoyed, comparatively, a greater amount of comfort by the old method of travelling. Sledges were far more convenient than those narrow seats allotted by the constructors to the public, particularly in the third-class carriages.† It is difficult to understand why the constructors of railways have neglected these important and essential conditions connected with the very nature of the undertaking. In support of our assertion, that the constructors of railways, in laying down rails between the towns, have by far not fulfilled all their duties and obligations, may be taken some of the railway companies of Western Europe, who, after a lapse of between thirty and forty years of the railway era, are only now beginning to amend the errors originally committed, by introducing that which had been formerly neglected. At the same time it may be mentioned that sleeping cars are becoming more and more general on American lines.

The construction of railways in Russia was commenced much later than in Western Europe, and it might, therefore, naturally have been expected that the various errors originally committed there, in connection with such undertakings, would have been obviated in our country. Our

* Some sleeping cars attached to the first-class carriages of the Nicolai Railway, have been constructed by the railway contractors, Messrs. Wynam Brothers, at Alexandroffsky, near St. Petersburg, on the American principle.

† A great portion of what we term the respectable classes, travel third class in Russia, particularly on the Nicolai (St. Petersburg and Moscow) line.

promoters, constructors, engineers, and contractors, with few exceptions, have all been abroad, and have had opportunities of witnessing and experiencing for themselves all the imperfections still attending the present systems. One might, consequently, reasonably have hoped, that with the introduction of railways into Russia, the dictates of experience would have been followed without repeating the faults committed by others; but, unfortunately, just the reverse has happened. Our railways are being constructed without any regard to an independent consideration, not only of local conditions, but in many instances of general requirement; and in this regard our constructors up till now have appeared only in the light of imitators of very bad precedents. We have ventured thus strongly to express our opinion, for the reason, that we perceive, that whatever there is useful and commendable abroad in connection with railway construction, is with difficulty adopted in this country, and that the most flagrant errors are in many cases multiplied, if not in cubic, then at any rate in square proportion. Those who have travelled on our lines may have very likely often remarked, that in most instances the stations are situated far away from the town, and, as a matter of course, were breaking their heads to find out the reasons of such a peculiar arrangement; the cause is, nevertheless, very simple, and is to be attributed to the predominance of the private interest of the constructors. Usually, when the construction of a railway is mooted near any particular town, the value of town property speedily rises. On that occasion commences immediately a struggle between the constructors and the town proprietors. The former demand sacrifices in their favor; the latter, finding this the only opportunity for an advantageous sale of their property, naturally hold out for high prices. Should they, thereupon, fail to come to terms, the constructors will then, often out of spite, as well as for private interests, carry the station as far as possible from the town, thereby depriving the latter of most important advantages. As a case in point may be cited an instance where, in consequence of differences of this kind, near one town had to be constructed an extra intermediate station—the chief station, with its refreshment departments, being situated eight miles off, in an open field.

Facts of this kind speak for themselves, and it is only to be wondered at that such proceedings should be tolerated in a country which has any pretensions to civilization. The Government, in granting concessions, could easily put a check upon this license practised by the constructors, and not allow the interests of whole districts and thousands of inhabitants to be for ever sacrificed to the momentary advantages gained by the constructors. The principal cause of abuses of this kind consists in this: that the persons obtaining the concession, and afterwards the construction, and finally the management of the railways, seldom form one and the same united body, and, therefore, easily escape from any responsibility for the injury occasioned to a district. The construction of a line of railway in Russia is usually proceeded with in the following manner: One or more persons, frequently individuals without any substantial means of their own, but who, solely in virtue of interest and their connections, secure the concession, and that at the highest possible figure—as with us in Russia, for instance, 75,000 Rs. per verst (£13,000 per English mile), order abroad all the requisite machinery, materials, and conclude all the necessary contracts with the different works at home; the verst of line costing them some 60,000 Rs., if not less, and, thereupon, having shared among themselves 15,000 or 20,000 Rs. per verst, netted in this manner, consider their business definitely terminated. On the formation of the management, and the handing over to it of the contracts, these constructors disappear altogether, interesting themselves very little in the future fortunes of the line. The contractors fulfil their engagements according to agreements, and the management accepts matters just as they stand, without, of course, having the power of, in any way, altering already accomplished facts. From this state of things it appears clearly evident that, for the constructors, it is an easy matter to erect a station at a distance, say, of five versts from a town, should the inhabitants have in any way incurred their displeasure, as it is not the former who expect to avail themselves of the railway. For all this will suffer the inhabitants of

the town, the merchants forwarding their goods, and the shareholders—all those most innocent of the cause of this abnormal state of things. Here lies the root of those causes by reason of which railways are so far from fulfilling their purpose and obligations. Were the constructors not merely speculators, were they connected with the lines by stronger bonds, they would then not have neglected a single detail in order to enable the railways to return the greatest possible profits and to secure for the public the greatest amount of convenience. In that case stations would not appear miles away from the towns, the railway companies would then themselves take charge of goods at the same place of their storage, delivering them at their destination; then would disappear those legions of agents, or commissionaries, with which both the passenger and goods traffic is beset at present; and the former, acting by means of an improved mode of transit, would then be enabled fully to replace the former carriers.

THE LOUISVILLE BRIDGE.

From "The Iron Age."

Work on the great railroad bridge over the Ohio, at Louisville, is so far advanced that the engineers are confident of being able to open it for the passage of regular trains by the 15th inst. Construction trains, however, will be able to pass several days sooner.

The total length of the iron superstructure is 5,280 ft., of which two spans are respectively 370 and 400 ft. long. The middle and Indiana channels are "over grade" or "through;" the others, varying in length from 50 to 250 ft., are "under grade" or deck. The under grade portion is of the same plan known as Fink's Patent Suspension Truss—a plan that has been well and favorably known for over 20 years.

The 400 ft. span now rests on its permanent bearings, and is in every respect satisfactory to its engineers. This, by the way, is the longest span ever erected in America, the next less being the main span of the Victoria Bridge, at Montreal, Canada, which is 330 ft. long, and the channel span of the Steubenville Bridge, which is 320 ft. long. The plan of truss is that known as the "triangular," one which has been extensively and successfully used by Mr. Fink, and has been in the present case especially arranged for this long span. The clear space above low-water line under this span is 96½ ft., and above high-water line 45¼ ft.; the total height from the rock bed of the river to the top of the upper chord of this span is 160 ft.

The total quantity of iron, wrought and cast, used in the construction of this great bridge, is 8,700,000 lbs., and the amount of timber including rails, joists, cross-ties and railway, will be 640,000 ft., board measure.

Considering the large number of men employed on the structure, and the character of the work, few accidents have occurred. In almost every case in which men have been killed or injured, it has resulted from their own carelessness. The company have taken particular pains to provide means of rescue for those who may fall into the river, and several skiffs, with two men in each, are always moored below, ready to give aid in case of emergency. Very few visitors are allowd on the bridge, for fear of accidents to them, where so many men are at work. One can get a pretty good idea of its immensity, however, from the city wharf, where numbers go every day to see it.

A curious work is going on near Ceylon, in the deepening of the sea channels between that island and India, by cutting away the connecting reef, so as to allow shipping of larger tonnage to pass. This has been in progress for 10 years, with a considerable increase of depth and of the number of ships. The work is executed by convict labor.

It is said that a Russian line of steamers from the Black Sea to Bombay, *via* the Suez Canal, is about to be established, with contracts already made by one house at Moscow to ship 4,000 bales of cotton per week.

THE HEATON STEEL PROCESS.

MONSIEUR GRUNER'S REPORT.

(*Continued from page 97.*)

V.—TENSION TESTS OF THE STEEL.

I have quoted in the preceding paragraphs some of the results obtained by Mr. Kirkaldy from his tension tests of the Moselle steel. I have united them in this Table with a view to readier comparison. I add the breaking strain calculated upon the area of fracture as well as the percentage of carbon which I found by the Eggertz method in the tested bars.

Description and Numbers of the bars.	Dimensions of the bars in inches.	Area of original section in square inches.	Breaking Load. (Original area). Tons per square inch.	Breaking Load. (Original area). Kilos. by millimetre-carre.	Breaking load in kilos. by sq. mm. of area of fracture.	Proportion of the area of fracture to original area.	Elongation per cent. on the original length.	Percentage of carbon in the tilted bars.	Notes.
No. 14. Cast steel (Longwy), second conversion. Mean of six tilted bars.....	½	0.267	49.5	77.90	109.7	0.71	12.5	0.0093	The fractures of all the bars present nearly the same appearance. It is granular, less fine, but more crystalline and more brilliant than the best steel. A characteristic of the fracture which seems to us peculiar to this metal is the appearance of two dark, dull bands along the diagonals of the square of the section.
No. 15. Cast steel (Longwy), third conversion. Mean of six tilted bars.....	½	0.267	52.0	81.9	87.1	0.94	4.0	0.0055	
No. 16. Cast steel (Longwy), fourth conversion. Mean of six tilted bars.....	½	0.266	49.1	77.3	84.9	0.91	6.0	0.0035	
No. 17. Cast steel (Hayanges), fifth conversion. Mean of four tilted bars.....	½	0.279	50.9	80.1	84.3	0.95	3.1	0.0037.	
No. 18. Cast steel (Hayanges), sixth conversion. Mean of four tilted bars.....	¾	0.562	37.8	59.5	61.1	0.97	1.3	0.0032	
No. 19. Cast steel (Hayanges), eighth conversion. Mean of four tilted bars..	½	0.275	50.3	79.2	83.9	0.94	3.2	0.0048	

To appreciate the real significance of the figures in this Table we must compare them with the results obtained from the steels of established reputation. Table F of Mr. Kirkaldy's work gives us the following results:

Description of the steels (⅜ in. to ¾ in. bars).	Breaking load in kilos. per square millimetre of the original area. Mean of many tests.	Breaking load in tons per square inch of original area.	Breaking load in kilos. per square millimetre of the area of fracture. Mean of many.	Breaking load in tons per square inch of area of fracture. (Mean).	Elongation per cent. of original length.	Character of fracture.
Turton tool steel.....	93	59	98	62	5.4	Fine Grain.
Jowitt chisel steel.....	88	55	105	67	7.1	"
Krupp cast steel, rolled for.....	60 to 67	41	97	62	15.3	Partly fibrous and silky lustre.
Shortbridge homogeneous iron, hammered.....	59 to 66	39	85	54	11.9	"
Jowitt spring steel, tilted.....	45 to 48	32	67	42	18.0	"
Mersey Company puddled steel, tilted..	47 to 53	32	77	49	19.1	Fibrous.

The percentages of carbon are not given, but we know by the use for which these steels are destined that the two first are hard steels, with a percentage of 0.006 to 0.010; the four last soft steels, or homogeneous iron, containing little more than

0.003 to 0.005 of carbon. By this we see that the Longwy steels produced from pigs containing but little silicon would be soft steels of fair tenacity but small elongation, especially so as to samples Nos. 15 and 16, obtained with a small charge of nitrate. The Hayanges steels show less tenacity and insufficient elongation. They are "short," though they contain a very small percentage of carbon, a defect which results from the presence of phosphorus not removed by the nitrate. Let us also compare the Moselle steels with the Swedish and Austrian steel. According to Mr. Kirkaldy's tests, the following are the results obtained by the Fagersta Bessemer steels:

Breaking Load.		Breaking Load.		Comparison of the area of fracture with the original area.	Elongation per cent. on the original length.	Percentage of carbon.
In tons per square inch.	In kilos. per sq. millim.	In tons per square inch.	In kilos. per sq. millim.			
Of original fracture.		Of area of fracture.				
59 to 69	93 to 109	57 to 64	89 to 103	0.91 to 0.95	2 to 6 per 100	0.0100
54 to 65	86 to 102	45 to 58	71 to 92	0.80 to 0.82	4 to 6 "	0.0070
58 to 65	90 to 103	45 to 46	70 to 73	0.68 to 0.82	9 to 10 "	0.0045
85 to	133 to 134	31 to	48 to 49	0.36 to 0.37	to 12 "	0.0035
53 to 58	106 to 119	26 to 26	42 to 44	0.37 to 0.46	11 to 22 "	0.0030

The Neuberg steels that have been tested at Vienna have yielded the results which are indicated in the following Table:

Breaking Load.		Elongation per cent. of the original length.	Percentage of carbon.	Observations.
In tons per sq. inch.	Kilos. per sq. mm.			
Original area.				
57 to 65	89 to 105	5 per 100	0.0088 to 0112	Brittle when too highly tempered.
46 to 57	73 to 89	5 to 10	0.0062 to 0088	Tempers well.
36 to 46	56.5 to 73	10 to 20	0.0038 to 0062	Ditto.
31 to 36	48 to 56.5	20 to 25	0.0015 to 0038	Hardens very little.
35 to 31	40 to 48	25 to 30	0.0005 to 0015	Does not harden at all.

In comparing these Tables we at once see the perfect agreement of the results obtained in the two countries. On the one hand, the elongation increases in proportion to the diminution of carbon in the steel; and, on the other hand, the breaking loads, as compared with the original area, decrease with the percentage of carbon, but, as compared with the area of fracture, vary very little. If, now, we compare these figures with those which we obtain in the case of the Moselle steels, we shall see that the elongation of the Swedish and Austrian steels, with 0.0045 to 0.0060 of carbon, is from 9 to 10 per 100; while in the case of the Moselle steels (Nos. 15 and 19) it only runs from 3 to 4 per 100. The breaking load, compared with the original area, is 51 to 52 tons in the case of these two Moselle samples, while in the case of the Swedish and Neuberg steels the maximum is 46 tons per sq. in. The strength is increased by the silicon and phosphorus; but the inferiority of the Moselle steel appears again when we compare the breaking loads calculated per sq. in. of the area of fracture. In the Swedish steel the breaking loads exceed 57 tons, and often 64 tons, while the No. 15 Longwy sample only reaches 54 tons (87 kilos.), and the Hayanges (No. 19) only 84 kilos.

Finally, when we compare the steels containing a low percentage of carbon—viz.,

from 0.0032 to 0.0037—we see that the elongation of the Swedish and Austrian samples reaches 12 and even 20 per cent. The Hayanges steel only reaches 3 per 100. The Longwy steels, more highly purified, are more ductile. The No. 14, produced with the maximum charge of nitrate, elongated 12.5 per cent. As to the breaking loads, calculated with reference to the original area, the Moselle samples generally give the best results, viz., 37 to 50 tons, instead of 30 to 36 tons; but calculated upon the area of fracture, the No. 14 only can compare with the Swedish steels. That gives 70 tons (109.7 kilos.), as against 105 to 134 kilos., while the steels Nos. 16 and 17, being less pure, only go to 84 and 85 kilos., and No. 18 only to 61 kilos. (38 tons). In a word, we may conclude from the foregoing analysis that the Heaton process does not readily produce hard steel of good body from phosphoric pigs, but that it will produce soft steel and homogeneous iron, which differ only from the common Bessemer steels by a somewhat greater stiffness and by a diminished tendency to elongation under heavy loads. It remains for us to show to what extent this defect is due to phosphorus, and to what extent it is possible to purify the metal by the Heaton process.

I will only remark, before I have done with the question of the quality of the steels, that, to be quite sure of the conclusion, we shall have to investigate their dynamic resistance as in the case of malleable iron. We shall only arrive at the relative value of the different steels by determining accurately the effect produced on the bars by loads which do not strain them beyond the limits of their elasticity.

VI.—CHEMICAL EXAMINATION OF THE PRODUCTS OF THE NITRATE REFINING PROCESS.

I have already given the analysis of the Moselle pigs. Now for the analysis of the crude nitrate used at Langley Mill. It was of consequence to determine the percentage of sulphur and phosphorus in the reagent used. The salt is yellow, in crystalline lumps. It was kept in a damp cellar at the works. Nitrate of soda, 90.89; chloride of sodium, 2.73 (containing chlorine 1.64); sulphate of lime, 0.22 (containing SO^3 0.12); sand, 0.28; water, 5.88; phosphoric acid, traces; total 100.00. Pure nitrate contains 36.61 per 100 of soda; consequently, the crude salt contains 33.27 per 100, or, if we add the soda in the chloride, 34.7 per 100.

The products of the Heaton refining process are crude steel and slags. The refined metal is itself converted partly into malleable iron and partly into steel. Let us examine each of these four products. Refined metal: The refined metal is a spongy mass, granular or crystalline, a kind of vesicular fine metal, the different parts of which are unequally purified. This lack of homogeneity is perceptible to the naked eye. The grain varies in size. I have a small sample of the second conversion, the large-grained portions of which, analyzed by the Eggertz method, give 0.0024 of carbon; the fine-grained, 0.0125, and a mixture of the two, 0.0045. The analyses I am about to give show also the somewhat unequal distribution of the silicon and phosphorus. At the moment when the converter bottom is upset on the floor of the works, we see that some portions of the solidified mass, being still fluid, disengage themselves and run off. These more fusible portions always contain more silicon and phosphorus than the solidified mass, and they are recognized in the laboratory by their greater resistance to nitric acid. To arrive at an accurate idea of the purification of the product it will not do to confine ourselves to an isolated examination of a sample of the refined metal. It is better to analyze the steel ingots produced by remelting in the crucible. There is another circumstance, too, which tends to falsify the results of this analysis. The vesicular metal always contains, intimately incrusted with it, or in the shape of a thin film in the interior of the bubbles (blisters), scoriacious matter (particles of slag), the existence of which is proved by analysis, but which cannot be thoroughly separated from the metal itself. And now let us give the results of some of the analyses of the refined metal, and see what deductions we may draw from them. But let me further remark that, in order to obtain results better admitting of comparison, I have preferred to analyze the cakes, that is, the refined metal rapidly reheated and shingled in the way I have described, rather than the spongy mass as it comes from the converter. This, I repeat, is always wanting in homogeneity, and more or less intermingled with slag. The cakes, it is true, are

not perfect in either respect, but they are certainly more uniform in texture. The cakes were analyzed, like the pigs, by dissolving five or ten grammes in nitric acid, evaporating to dryness, calcining the product to render the silica insoluble, taking up the oxides by hydrochloric acid, precipitating the iron in the state of sulphide, and determining the phosphorus in the condition of phosphate of magnesia. This phospate, be it said, was dissolved and reprecipitated to make sure of its purity; and the soluble silica, which is always to some extent taken up by the sulphide of iron and the phosphate of magnesia, was accurately determined. The sulphur was tested separately, either by the common method or by the Eggertz method; then the carbon was determined by the Eggertz method. I did not determine the other ingredients, unless perhaps the sodium in one of the samples; and, besides, I ascertained the presence of very decided traces of vanadium in the pigs. It is perceptible even in the steels, though the greater part of it passes into the slag in the form of vanadate of soda. We analyzed four cakes; they were the products of the first conversions of Longwy pig and the two first of Hayanges pig. The Longwy cakes were flattened cold under the hammer, and dissolved easily in nitric acid; the Hayanges cakes are harder and finer-grained; they will not hammer out cold, and will not dissolve in nitric acid unless heat be applied. There are indications of a less perfect purification, which, in fact, are confirmed by the analyses. Here are the figures:—

Ingredients tested.	Conversion No. 1.	Conversion No. 2.	Conversion No. 3.	Conversion No. 6.	Remarks.
Undissolved slag	0.0020	0.0006	0.0025	0.0078	All the silica figures here as silicon, though part of it must have been due to the slag intermixed with the metal.
Silicon	0.0016	0.0014	0.0053	0.0045	
Phosphorus	0.0064	0.0059	0.0092	0.0078	
Sulphur	0.0019	....	0.0001	....	
Carbon	0.0120	0.0125	0.0121	0.0152	

We will begin by observing that the figures placed opposite the undissolved slag do not represent the whole amount of slag intermixed with the metal.

The slag is decomposed for the analysis by acids. These separate from it a basic portion which is dissolved, while the residue is an acid silicate which we isolate from the true silica by removing the latter in an aqueous solution of caustic potash. The quantity dissolved by the acids is in proportion to the basic character of the slag itself. Now, in this respect there is a great difference, as we shall presently see, between the slags resulting from conversions Nos. 1 and 2 and those of conversions Nos. 5 and 6. These last contain more than 50 per cent. of silica—the former about 30 per cent. These consequently leave a smaller residue, and as they contain 15 to 16 per cent. of phosphoric acid, while the slags of conversions Nos. 5 and 6 do not contain 2 per cent., it follows that an appreciable quantity of the phosphorus given in the analysis of the refined metal of Nos. 1 and 2 must come from the adherent slags. One per cent. of true slag mingled with the metal would suffice to contribute 0.0016 of phosphoric acid, or 0.0007 of phosphorus to the analysis of the cakes. Thence it follows that in the refined metal, the produce of conversions Nos. 1 and 2, the proportions of phosphorus should be really about 0.0055 or 0.0050, instead of 0.0064 or 0.0059.

This being the case, we see, on comparing these analyses with the analyses of the pigs, that the gray silicious pigs are far less purified than the white pigs—that the silicon oxidizes before the phosphorus, and that the carbon oxidizes last. But unfortunately we see that, even in the most favorable case, the dephosphorization is far from complete. The purified product still retains 0.005 of phosphorus when we deal with pigs which contain 0.014 to 0.015. However, this conclusion must not be taken as *absolute*. The purification depends on the percentage of nitrate used; besides, we must remember that, the refined metal not being homogeneous, we must consult the analysis of the steel ingots to ascertain the true de-

phosphorization. We find a proof of the lack of homogeneity in the fact that the metal No. 1 retains more phosphorus than No. 2, while the reverse ought to be the case according to the charges of nitrate used in the conversions. In any event, if we refer to the observations made at Konigshutte on the refining of phosphoric pigs by the Bessemer process, we must not be astonished if cast-steel with as much as 0.005 of phosphorus should work almost as well when hot as pure steel. Dr. Miller, of King's College, found 0.0014 of sodium in the refined metal—in fact, I believe it always contains some. The soda, in percolating the molten metal, is, like the nitric acid, partially deoxidized by the carbon and the iron, but it is impossible to determine the sodium accurately on account of the presence of slag in the iron. I did indeed try—by treating the crude steel with hot water—to dissolve the soda belonging to the slag, but the slag only yields a portion of its alkali to the water, so that when we subsequently endeavor to determine the sodium in the washed metal, we cannot tell whether or not it comes from the crude steel or the associated slag. However that may be, the refined metal of the third conversion gave me 0.0006 of sodium, after having been, as far as possible, deprived of the adherent slag—by washing in boiling water—at the risk, it is true, of also dissolving a portion of the true sodium. In any event, the alkaline metal ought to be rather beneficial to the final product. In the final melting for cast-steel it ought to act again upon the phosphorus and sulphur.

Slags.—The second product of the Heaton process is the akaline scoria resulting from the action of the nitrate of soda. I restricted myself to a complete analysis of two samples—the slag of the first and fifth conversions. But I satisfied myself that the slags of the first four conversions are nearly identical, as also those of the four last conversions. We have already seen that they are of two very distinct types—due to the different proportions of silicon in the pigs. These are the results:

Elements determined.	Slag of the first conversion. Longwy white pig.	Slag of the fifth conversion. Hayanges gray pig	Slag of the eighth conversion, partially analyzed.
Silica	0.310	0.540	0.545
Phosphoric acid	0.158	0.016	0.018
Sulphuric acid	0.007	0.005	.....
Sulphur	0.006		.....
Chlorine	0.007	0.002	.....
Soda	0.304	0.290	0.305
Lime	0.010	0.008	0.005
Magnesia	traces	0.004	.....
Protoxide of iron	0.144	0.080	0.080
Protoxide of manganese	0.046	0.041	0.034
Oxide of vanadium	0.005	0.006	.....
Sulphur, chlorine, vanadium, magnesium, etc., by difference	.....	.....	.013
	0.997	0.992	1000

The slags resulting from the two varieties of pig contain the same elements and nearly the same proportion of soda, but the opaque dull slags of the Longwy white pig are rich in phosphoric acid, while the vitreous slags of the Hayanges gray pigs are silicious, so that the character of the slags tends to support the conclusions already arrived at as to the more imperfect purification of the silicious pigs. The proportion of oxide of iron is also less in the silicious slags of the Hayanges pig than in those of the Longwy pig; but in both cases the percentage of iron is small, and the waste altogether minimum. In the conversions of the Longwy pig the weight of the slag is, in fact, as we shall see, about 60 kilos. (132 lbs.), that is to say, less than 9 per cent. of the weight of the pig metal refined. Now the 0.144 of protoxide of iron corresponds to 0.112 of metallic iron, of which

the 9 per cent. make 0.0101 ; which proves that the nitrate has not oxidized more than 1 per cent. of the pig treated. On the other hand, in treating the Hayanges pigs the maximum weight of the slags is 85 kilos. (187 lbs.), say 12 per cent. of the weight of the pig, and as the scoria contains only 0.08 of protoxide of iron, or 0.062 of metallic iron, the pig has only parted with 0.062 of the 12 per cent. to the slag—say, 0.0086 of metallic iron—that is, less than 1 per cent. We see, then, that in this process the waste of iron is almost *nil*, and that the waste is solely due to the oxidizing of foreign matters. This confirms the figures of 6 per cent. above given, as the mean of the results obtained from the Hayanges pig conversions.

The slags contain metallic shot or globules ; these were carefully separated by means of a magnet before analysis. The slag of the first conversion yielded 8.3 per cent. of shot, those of the fifth and eighth conversions between 5 and 6 per cent.; but these figures are variable, depending on the choice of samples ; and in general, as we shall see, the percentage of shot is higher. The pigs of Longwy and Hayanges, as we have already said, yield very different slags. Water and acids do not dissolve them in the same way.

Water easily decomposes the slag of the Longwy pig. The result is a green solution, which turns yellow after parting with a slight black deposit. The liquor contains a sulphide of sodium, which blackens silver, and it is this compound which first of all retains a little sulphide of iron and keeps in solution the sulphide of vanadium. Water, however, only removes a portion of the soda. It transforms the silico-phosphate into a basic compound soluble in water, chiefly formed of phosphate of soda, and into an insoluble residue retaining the greater part of the silica, about one-third of the phosphoric acid, and all the non-alkaline bases. The vanadium also is partly retained by the insoluble silicate.

When we moisten the slag and leave it exposed to the air, it partially decomposes. The silicate of soda is transformed to carbonate. In treating the slag of the first conversion with water, 0.386 of it is dissolved, and we find in the solution 8 to 9 per cent. of silica, 25 per cent. of phosphoric acid, and 62 per cent. of soda, while the insoluble residue is composed of 50 per cent. of silica, 9 to 10 per cent. of phosphoric acid, 10 to 11 per cent of soda, and about 30 per cent. of oxides of iron, manganese, etc. If we compare these figures with those of the analyses, we see that water removes about five-sixths of the soda, one-tenth of the silica, and two-thirds of the phosphoric acid.

Hydrochloric acid completely dissolves the Longwy slag. Sulphuretted hydrogen is liberated. On evaporating to dryness and redissolving in acid there is generally a residue of pure silica, but if it is overheated, and the acid employed is not very concentrated, it may also happen that the silica will retain various phosphates which the acids will not take up. The vanadium is chiefly concentrated in the alkaline solution, but is also partially taken up by the phospate of magnesia. The blue tint of the salts and the red coloring of the ammoniacal sulphate of vanadium leave no doubt upon this point. I have besides proved the absence of chrome, and verified the formation of vanadic acid by treatment with nitre.

Water also dissolves the Hayanges slags. When hot the liquor is colored brown (viz., sulpho-vanadate of soda), but the solution is chiefly composed of silicate of soda with an excess of base. The slag No. 5 yields 0.39 of its weight to water; the slag of No. 8, 0.34. In both cases the insoluble residue softens at a low red heat. The aqueous solution contains two-thirds of the soda, half the phosphoric acid, and nearly one-third of the silicic acid. Neither hydrochloric acid nor sulphuric acid entirely dissolves the Hayanges slag. It is too silicious for that. The residue is a silico-phosphate with an excess of acid, forming from 0.25 to 0.30 of the original slag. To determine the silica we treated the substance with a mixture of carbonate of soda and nitre; we so obtained silica tinted somewhat yellow by the vanadic acid. To determine the soda we used hydrochloric and sulphuric acid.

In all the slags, but especially in that of the Hayanges pigs, the sulphur is a little oxidized. It is generally found in them combined with sodium, so that, in spite of the presence of nitric acid, the soda equally gives up a part of its oxygen to the oxidizable elements of the pig.

Now let us try, by the aid of these an-

alyses which I have given, to determine the degree of refinement at which it is possible to arrive by the Heaton process. To this end, let us first calculate the quality of oxygen which the nitrate can supply. Assume that the nitric acid be simply reduced to the condition of dentoxide of nitrogen, but that the water in the nitrate be entirely decomposed, 100 kils. (220 lbs.) of Peruvian nitrate would liberate—for the 90.89 kilos. of pure nitrate, 25.5 kilos. of oxygen, equal to 55½ lbs.; and for the 5.88 kilos. of water, 5.2 kilos. of oxygen, equal to 11.4 lbs. If, on the contrary, the nitric acid were completely decomposed, we should have—for the 90.89 kilos. of nitrate, 42.5 kilos. of oxygen, equal to 93.4 lbs.; and for the 5.88 kilos. of water, 5.2 of oxygen, equal to 11.44 lbs. Total 47.7 kilos., equal to 196 lbs. Let us compare with these figures the quantity of oxygen which would be requisite for the complete oxidization of all the foreign elements in the Moselle pig. We will take first of all the Longwy pig of the first conversion. The weight converted was 720 kilos., equal to 15.84 lbs., irrespective of the two iron bars. Assuming, according to the foregoing analysis, 0.9 per cent. of silicon, 1.42 per cent. of phosphorus, ½ per cent. of sulphur, and 3 per cent. of carbon, of which about the half had to be expelled, there would be required to oxidize these elements :

	kilos.	lbs.		kilos.	lbs.	
For the 0.9 p. c. say	6.48	14	silicon	7.02	15.444	oxygen.
" 1.42 "	10.22	22.48	phosphorus	13.01	28.6	"
" ½ "	2.40	5.28	sulphur	2.40	5.28	"
" 1.5 "	10.80	23.76	carbon transformed into carbonic oxide.	14.40	31.68	"
			Total	36.83	81.004	

Now, for the first conversion there were used 68 kilos. (149 lbs.) of nitrate, which would yield on the first hypothesis, 20.88 kilos (45.9 lbs.) of oxygen, and on the second 32.44 kilos. (71.3 lbs.) of oxygen. We see, then, that on the most favorable theory the proportion of oxygen yielded by the nitrate was insufficient to oxidize all the impurities. A *fortiori*, it must have been so in practice, since, putting aside the iron, we have to take into account the oxygen taken up by the manganese, the vanadium, the earthy metals, etc., contained in the pigs; and, on the other hand, the nitrous gas, which we see evolved during the conversion, proves that at least a portion of the nitric acid is simply reduced to the state of dentoxide of nitrogen. It is not, therefore, to be wondered at that the refined metal should still retain some phosphorus and silicon, and that a very small quantity of iron should have been oxidized. One can understand, too, that the soda itself may be partially reduced under these circumstances.

Let us calculate by the analysis of the cakes of the first conversion how much oxygen would be requisite to complete the refining of the converted metal. The weight of this product, reckoning the splashes of metal, was, in this conversion, 1470 lbs. (669 kilos.); or, rather, if we add the weight of metallic shot found in the slag, 671 kilos. (1476 lbs.), this will give us:

	kilos.	lbs.	kilos.	lbs.	
For the 0.0016 of silicon, say	1.07	2.354	1.16	2.552	oxygen.
" 0.0064 of phosphorus, say	4.29	9.438	5.46	12.012	"
" 0.0009 of sulphur, say	0.60	1.320	0.60	1.320	"
Total	13.112		7.22	15.884	

Now this is a minimum, since the cakes, owing to the oxidizing reheating, are purer than the spongy metal as it comes out of the converter. Deducting the 15.8 lbs. from the 81 lbs., we see that to arrive at the result obtained, the nitrate should have furnished 65 lbs. of oxygen, say 44 per cent. Consequently, the greater part of the nitric acid must have been converted to nitrogen, or to protoxide of nitrogen. We see, too, that to obtain the indispensable proportions of oxygen, the charge of nitrate should have been increased by at least 15 kilos. (33 lbs.) But even then, the purification would not have been complete, since some portion of the oxygen in question would have reacted on the iron and the carbon. If, then, the

bar iron, prepared from the refined metal of the first conversion, shows the characteristics of burnt iron, we must attribute it to the reheatings, and not to an excess of nitrate in the converter. The analyses, in fact, as well as the remeltings for steel, prove that the cakes resulting from the first conversion were sufficiently carburized. But, had they not been so, I should not, on this account, fear an excess of nitrate. It would be always easy to restore the proper percentage of carbon to the refined metal. It would suffice to add at the remelting for steel a sufficiently large percentage of pure spiegeleisen, as is done in the Bessemer and Martin processes.

There would, however, be two objections to the use of an excess of nitrate. In spite of the extra heat which would be evolved, we might fear that the metal would not remain fluid to the last, and that it might in consequence lose its homogeneity; and then there would be the extra cost; instead of 68 kilos. (150 lbs.) of nitrate, 83 or 85 kilos. (182 lbs. or 187 lbs.) would be required, say 11½ or 12 per cent. instead of 9½ per cent.

The refined product is not homogeneous, and would no doubt be even less so if the decarburization were more advanced. But this seems to me to be a matter of small consequence, since, in any event, the refined product has to be remelted in the reverberatory furnace. It is perfectly evident that the most economical method would be to run the refined metal straight from the converter into the reverberatory furnace, which appears to me to be easy to manage. As to the cost of these heavy charges of nitrate, we cannot pretend to ignore the fact that it will be large, especially at the present price of nitrate. But on this head I propose presently to suggest a modification of the process which would allow of the charge of nitrate being very considerably reduced.

Let us go into the same calculations with regard to the Hayanges gray pig. According to the analyses I have given, the remelted Hayanges pig contains 3 per cent. of silicon, 1.27 per cent. of phosphorus, 0.1 per cent. of sulphur, and 3 per cent. of carbon. If we propose, as above, to remove only half the carbon, we should require to oxidize these elements in a charge of 705.7 kilos. (13 cwt. 95 lbs.) of pig, which was the weight of the three last conversions—the following quantities of oxygen—for 3 per cent., or 45 lbs. of silicon, 50 lbs. of oxygen; for 1.275 per cent., 20 lbs. of phosphorus, 25 lbs. of oxygen; for 0.10 per cent. or 1.6 lbs. of sulphur, 1⅓ lbs. of oxygen; for 1.50 per cent. or 23 lbs. of carbon, 31 lbs. of oxygen; total, 108 lbs. of oxygen. Assuming that the nitric acid gave up all its oxygen, these 108 lbs. would have required 226.6 lbs. of nitrate; now the maximum used was 199 lbs. The purification, then, could not be complete, and all the less so that the nitric acid is not entirely decomposed, and that the iron, the manganese, and the other elements absorbed at least 11 lbs. of oxygen, or 24 lbs. of nitrate, according to the proportion of metallic oxides in the slags. *A fortiori*, then, we need not be astonished if the metal produced by the fifth and sixth conversions still contains a notable percentage of phosphorus and silicon, since only 147 lbs. of nitrate were used in the fifth, and but 169 lbs. in the sixth conversion.

Let us calculate how much oxygen would have been required to finish the refining in the fifth conversion.

The refined metal weighed 647 kilos. (1,423 lbs.); or if we add the 5.2 per 100 of shot in the 114 kilos. (250 lbs.) of slags, 653 kilos. (1,436 lbs.). Now, taking the analysis of the cakes which we have given above, the 653 kilos. (1,436 lbs.) contain 0.0053, or 3.46 kilos., equal to 7 lbs. of silicon, which would have required 3.75 lbs. equal to 8.250 lbs. oxygen; 0.0092, or 6.01 kilos., equal to 13 lbs. of phosphorus, which would have required 7.69 kilos., equal to 16.9 lbs. oxygen; 0.0001, or 0.06 kilos., equal to 0.13 lbs. of sulphur, which would have required 0.06 kilos., equal to 0.13 lbs. oxygen; total, 11.50 kilos., equal to 25.3 lbs. of oxygen.

And these 11.50 kilos. (25 lbs.) are a minimum, seeing that the crude steel, as it comes from the converter, is not so pure as the cakes; and when we consider, too, that the alkaline salt is not completely decomposed, we see that the charge of nitrate should have been augmented by at least 30 or 35 kilos. (66 lbs. or 77 lbs.), which would bring us nearly to the same figure we before arrived at—103 kilos. (226 lbs.)—and shows us that in any event, instead of 9.4 per cent. of nitrate, 14 or 15 per cent. should have been used. Hence it is evident that the refining of silicious brands by the Heaton process

would be too costly, and that we must, in any event restrict its use to white pigs, the price of which, however, as we all know, is less than that of gray pig.

Now let us ascertain from the analyses what becomes of the soda of the nitrate and the phosphorus of the pig in the converter. If we knew the exact weight of the slags, and if they were as homogeneous as the cakes, we could calculate from the analyses the quantities of phosphoric acid and soda carried off in the slag, and compare the result with the quantities in the pig and in the nitrate. We can do so approximately in the case of the Hayanges pigs; it is more difficult in the case of the Longwy pigs, the slags from which are scarcely homogeneous and but little fluid. A considerable quantity of them adhered to the lining of the converter, and could not be weighed.

We will first of all see what we can learn from the slags of conversion No. 5. They weigh 114 kilos. (250 lbs.); or, if we deduct the 5.2 of metallic shot, 108 kilos. (237 lbs.). But it is easy to see that this figure of 108 kilos. (237 lbs.) is too high, for the slag would contain more soda than the nitrate itself could have yielded. The same observation applies to the slag of the last three conversions. The mass weighed certainly contains more globules of metal than the sample chosen for analysis. We arrive at the same conclusion, too, by calculation. As the lining of the converter is hardly at all attacked by the nitrate, we can reckon approximatively the weight of the slag by the amount of silica that would be yielded by the pig and the sand.

We have already seen that the 706.8 kilos. (13.91 cwt.) of pig converted in the fifth operation contain 3 per cent. of silicon, say, 21.20 kilos. (46.6 lbs.); the cakes retain after conversion, 3.40 kilos. (7.9 lbs.); the difference, say, 17.74 kilos. (38.4 lbs.) represents the silicon given up to the slag. The corresponding weight of silica is 36.96 kilos. (81 lbs.); we must add the silica of the sand used as a diluent, 9.36 kilos. (20 lbs.), and the result is for the silica of the slag, 46.32 kilos. (101 lbs.).

And as by the analysis the slags contain 0.54 of silica, we find the weight of the slags to be

$$101 \times \frac{100}{.54} = 187 \text{ lbs.}$$

This weight is probably still in excess of the truth, because the silicon returned in the refined metal is probably rather greater than what is shown by analyses of the cakes. If, however, we admit these figures, we shall find that the analysis will give us for the quantity of soda, $0.29 \times 85 = 24.65$ kilos.$=54$ lbs. On the other hand, as 100 parts of crude nitrate yield a maximum of 34.7 of soda, we see that the 67 kilos. (147 lbs.) of nitrate used in this conversion could only have yielded 23.25 kilos. (51 lbs.) of soda. These results do not exactly agree, and that goes to prove what I said—that the weight of the slag could hardly have been more than 80 kilos. (176 lbs.). We may, however, deduce this further conclusion, viz., that very little of the soda could have escaped the action of the silica, and that very little could have been volatilized, or passed in the shape of sodium into the refined metal.

Let us apply the same calculations to the phosphorus. The pig converted contains 9.01 kilos. (19.8 lbs.) of phosphorus; the cakes retain of it 6.01 kilos. (133 lbs.); the weight eliminated from pig is 3.00 kilos. (6.6 lbs.), which ought to have yielded 6.80 kilos. of phosphoric acid.

Now, reckoning the contents in phosphorus of the slag at 0.016, the 85 kilos. (187 lbs.) of slag only contain 1.360 kilos. (2.9 lbs.); that is to say, the one-fifth part of the phosphorus eliminated from the pig. The difference is so great that we must conclude that in the presence of excess of silica the greater part of the phosphorus must have been volatilized, either in the form of free phosphorus, phosphorous acid, or phosphoric acid.

We have not all the materials for working out these calculations for the sixth and eighth conversions. We can, however, ascertain that the weight of slag must have been between 80 and 100 kilos. —that almost the whole of the soda is contained in them, and that the greater part of the phosphorus eliminated has been volatilized.

If we now repeat these calculations for the Longwy slags, which contain little silica, we shall find the results will be very different. Let us examine the first conversion. The 720 kilos. (1,584 lbs.) of pig converted at 0.009 of silicon contain 6.48 kilos. (14 lbs.); the cakes at 0.0016 retain of it 1.07 (2 lbs.); there remains of

silicon passed into the slag, 5.41 kilos. (12 lbs.); which corresponds to silica, 11.27 kilos. (24.6 lbs.); we have to add for the .9 of silica from the diluent sand, 8.10 kilos. (18 lbs.); which will give as the total silica of the slags, 19.37 kilos. (42 lbs.). Consequently, as the slags contain 0.31 per cent. of silica, we have as their total weight

$$19.37 \times \frac{100}{31} = 62 \text{ kilos.} = 136 \text{ lbs.}$$

$$42 \times \frac{100}{31} = 136 \text{ lbs.}$$

This figure is much higher than the 25 kilos. (55 lbs.) found by experiments; but I have already observed that these basic slags are very pasty, and that a very considerable percentage of them adheres to the lining of the converter. On the other hand, the figure of 62 kilos. (136 lbs.) is perhaps rather too high, because, as I before said, the refined metal ought to retain more silicon than the cakes do. We must, then, consider these 62 kilos. (136 lbs.) as a maximum. Consequently, as the slags by analysis contain 0.304 of soda, we shall have also for the alkaline bases, on multiplying the 62 kilos. (136 lbs.) by 0.304, a maximum of 18.85 kilos., or 41 lbs.

Now, on the other hand, the 68 kilos. (150 lbs.) of nitrate ought to have yielded the still higher figure of 23.60 kilos. (51 lbs.) of soda, an incontestable proof that a notable quantity of soda, ill-retained by the silica, has either disappeared during the conversion in the form of vapor, or has combined with the iron in the form of sodium.

As to the phosphorus, we find the results: Phosphorus in the pig, 10.22 kilos. (22.4 lbs.); phosphorus retained by the cakes, 4.29 kilos. (9 lbs.); phosphorus eliminated, 5.93 kilos. (13 lbs.); a weight which corresponds to 13.48 kilos. (2.96 lbs.) of phosphoric acid. Now the 62 kilos. (136 lbs.) of slag, which yielded 0.158 of phosphoric acid, contain 9.80 kilos. (21.4 lbs.); and this, too, must be taken as a maximum. So not more than two-thirds of the phosphorus eliminated are really retained by the slag. There is, consequently, still a loss by volatilization, but it is not nearly so great as in the case of the Hayanges pig. There the soda, more entangled by the silica, acts less energetically on the phosphoric acid. We have here a new proof of the influence of silicious slags on phosphoric compounds at high temperatures.

These considerations will now permit us to investigate the chemical reactions which take place in the Heaton converter, and to explain the very varied phenomena which are exhibited. When the molten metal reaches the nitrate the latter is at once decomposed; the nitric acid is at once reduced to the condition of nitrogen, or protoxide of nitrogen; but there is also formed a little oxide, which we recognize by the reddish vapors which escape from the converter.

The oxygen of the nitre first seizes on the silicon, the phosphorus and the sulphur hold out longer, the carbon longest of all. A part of the sulphur passes into the slag in the form of sulphuret of sodium. Of the metals the manganese, and no doubt also the metallic earths, are to a great extent oxidized; the iron is hardly acted on at all, so long as there is no excess of nitrate used. Only a portion of the oxidized products is found in the slag. The carbon escapes in the form of carbonic oxide. The slag contains no trace of carbonate of soda; the silicon, indeed, transformed into silica, is completely retained in the slag by the soda and other bases. The phosphorus holds an intermediate position between these two substances, both as regards its distribution among the oxidized products and as regards its property of oxidization. Some portion of it forms phosphate of soda; some escapes in the form of vapors more or less oxidized. The relative quantities of phosphate and vapors depend on the degree of saturation of the soda by the silica, and probably, also, on the temperature. If we wish to retain the phosphoric acid, we must not mix silicious sand with the nitrate.

(TO BE CONTINUED.)

ATTENTION is being drawn in different parts of the country to the alterations which the climate of Australia is undergoing, in consequence of the systematic denudation of tree covering which the surface of the conntry is being subjected to. The Government of Victoria have appointed an Inspector of State Forests, whose duty it will be to prevent the waste of timber and the reckless destruction of live wood, and at the same time to establish nurseries of forest trees in various parts of the colony.

RAILWAY RESISTANCE.

From "Engineering."

We have been lately favored with the details of some experiments made on the Southern and Western Railway, of Queensland, in May last, to determine the relative resistances to traction on the various gradients and curves on that line; and although these experiments present certain inconsistencies which render it impossible to deduce from them any precise rule for calculating the resistance due to a curve of any given radius, yet they possess for many of our readers an interest far more than sufficient to entitle them to a record in our pages, and we therefore propose to give an account of them in the present notice. The Queensland railways, of which we gave a description in our last number, are, as most of our readers are aware, of 3 ft. 6 in. gauge, and it is this peculiarity in the gauge which gives the experiments just referred to special interest. The experiments were made by Mr. J. F. L. Jetter, the locomotive superintendent of the line, and they consisted in drawing over the latter, from Murphy's Creek to Troowoomba, at a speed of 10 miles per hour, a train of seven vehicles, the tractive force required at the different portions of the journey being carefully ascertained by means of a dynamometer. The train was made up of six empty wagons and a brake van, the latter containing 10 cwt. of ballast. The weights, etc., of the vehicles are as follows:

	Weight. tons.	cwt.	qrs.		No. of wheels.
Brake van.....	5	14	1	.....	4
Covered goods wagon.	3	18	1	.....	4
Carriage truck.....	2	15	0	.....	4
Covered goods wagon.	5	8	2	.....	6
Low sided "	4	19	0	.....	6
" "	4	19	0	.....	6
" "	4	19	0	.....	6
Total gross weight	32	13	0	.....	36

We gave particulars of the rolling stock for the Queensland lines, on pages 174 and 196 of our second volume; but we may mention here that the wagons have wheels 2 ft. in diameter, and that the wheel base of the four-wheeled vehicles is 7 ft. The six-wheeled vehicles have, we believe, a wheel base of 15 ft.; but they are fitted with Mr. John Clark's arrangement for enabling the wheels to adjust themselves to curves, so that the long wheel base does not increase the frictional resistance.

With a view of, in the first place, ascertaining what we may call the normal frictional resistance of the Queensland rolling stock, at the speed of 10 miles per hour, we have selected from Mr. Jetter's experiments, those made on the straight portions of the line, and embodied them in the annexed Table, No. I.

TABLE No. I.,

SHOWING THE RESISTANCES ON THE STRAIGHT PORTIONS OF THE LINE.

Weight of Train, 32 tons, 13 cwt. Speed, 10 miles per hour.

Gradient.	Strain on dynamometer in cwts.	Total resistance of train in pounds per ton.	Resistance in pounds per ton due to gravity.	Frictional resistance in pounds per ton.
Level.	5	17.15	...	17.15
1 in 625.....	5½	18.87	3.58	15.29
1 in 120.....	10	34.30	18.66	15.64
1 in 98.....	12	41.16	22.85	18.31
1 in 87.....	13	44.59	25.74	18.85
1 in 81.....	13½	46.30	27.65	18.65
1 in 66.....	15	51.45	33.94	17.51
1 in 60.....	15	51.45	37.33	14.12
1 in 55.....	16½	56.60	40.72	15.88
1 in 50.....	18	61.74	44.80	16.94
Mean frictional resistance in pounds per ton =.....				16.84

The data given by Mr. Jetter are, the weight of the train, the gradients, and the tractive force required, in cwts., and from the first and last of these data we have

calculated the total resistances of the train, in pounds per ton, as given in the third column of the Table. Deducting from these amounts the resistance due to gravity in each case, we get the remainders given in the last column of the Table, which represent the frictional resistance of the train in pounds per ton. These results, it will be seen, agree very fairly with each other; but their mean, 16.84 lbs. per ton, is certainly extremely high, even when the small diameter of the wheels is considered. To some extent this high frictional resistance may be due to the train being composed of *empty* wagons, the friction of empty railway vehicles being generally slightly greater per ton than that of the same vehicles when loaded; but this cause would only account for a small portion of the resistance, which is most certainly excessive, and can only be caused by some defects in the construction or state of maintenance of the rolling stock. The resistance is, in fact, so high that we should have hesitated to accept the data as correct had not the coincidence in the results obtained on the various gradients shown conclusively the correctness of the dynamometric indications.

The frictional resistance on the straight

TABLE No. II.,

SHOWING THE RESISTANCES ON THE CURVED PORTIONS OF THE LINE.

Weight of Train, 32 *tons* 13 *cwt.* *Speed*, 10 *miles per Hour.*

Reference Number.	Radius of Curve in Chains.	Gradient.	Strain on Dynamometer in cwts.	Total Resistance of Train in Pounds per Ton.	Resistance due to Gravity in Pounds per Ton.	Resistance, in Pounds per Ton, due to Friction—Total Resistance—Resistance due to Gravity.	Resistance due to Curve in Pounds per Ton—Total Resistance—Mean Frictional Resistance on Straight Line + Resistance due to Gravity.
1	57½	1 in 120	11	37.74	18.66	18.08	2.24
2	20	1 " 88	15	51.45	25 45	26.00	9.16
3	20	1 " 60	16	54.88	37.33	17.55	0.71
4	15	1 " 50	20	68.60	44.80	23.80	6.96
5	12	1 " 60	17	58.31	37.33	20.98	4.14
6	10	1 " 100	13½	46.30	22.40	23.90	7.06
7	10	1 " 50	19	65.17	44.80	20.37	3.52
8	9½	1 " 80	14	48.02	28.00	20.02	3.18
9	9	1 " 50	21	72.03	44.80	27.23	10 39
10	8	1 " 112	12	41.16	20.00	21 16	4.32
11	8	1 " 60	16	54.88	37.33	17 55	0.71
12	8	1 " 50	19½	66 89	44.80	22.09	5.25
13	7	1 " 226	10	34.30	9.91	24 39	7.55
14	7	1 " 110	13	44.59	20.36	24.23	7.49
15	7	1 " 50	21	72.03	44.80	27.23	10.39
16	6½	1 " 50	22	75.48	44.80	30.68	13.84
17	6	1 " 80	14	48.02	28.00	20.02	3.18
18	6	1 " 50	22½	77.18	44.80	32.38	15.54
19	5½	1 " 71	16	54.88	31.55	23.33	6.49
20	5½	1 " 64	16½	56.60	32.50	24.10	7.26
21	5½	1 " 60	17½	60.03	37.33	22.70	5.86
22	5	Level.	6	20.58	.....	.....	3.74
23	5	1 " 625	7	24.01	3 58	20.43	3.59
24	5	1 " 300	8	27.44	7.47	19.97	3.13
25	5	1 " 110	14	48.02	20.36	27.66	10.82
26	5	1 " 105	14	48.02	21.33	26.69	9.85
27	5	1 " 100	14	48.02	22.40	25.62	8.78
28	5	1 " 80	16	54.88	28.00	26.88	10.04
29	5	1 " 74	18	61.74	30.26	31.48	14 64
30	5	1 " 65	19	65.17	34.46	33.71	13.87
31	5	1 " 60	21	72.03	37.33	34.70	17.86

portions of the line being ascertained, the increase in that resistance due to the various curves can be readily determined from Mr. Jetter's other experiments, the details of which are included in the first four columns of Table No. II. From these data, we have, as before, calculated the total resistance of the train in pounds per ton (*vide* fifth column of the Table), and deducting from these amounts the resistance due to gravity in each case, we get the frictional resistances on the various curves as given in the seventh column of the Table. Deducting again from these last-mentioned resistances the normal frictional resistance on the straight portions of the line, as before determined, we get the remainders included in the last column of the Table, these representing the increase in the normal frictional resistance (in pounds per ton) due to the various curves, of which the radii, in chains, are given in the second column of the Table.

TABLE No. III,

SHOWING THE INCREASE OF FRICTIONAL RESISTANCE DUE TO CURVATURE.

Gauge of Line, 3 *ft.* 6 *in. Train consisting of seven vehicles weighing* 32 *tons,* 13 *cwt. gross. Speed,* 10 *miles per hour.*

Radius of curves in chains.	Number of experiments from which the results are deduced.	Increase in frictional resistance due to curvature, expressed in pounds per ton. Value, deduced from Table No. II.		
		Maximum.	Minimum.	Mean.
57½	1	2.24	2.24	2.24
20	2	9.16	0.71	4.93
15	1	6.96	6.96	6 96
12	1	4.14	4.14	4.14
10	2	7.06	3.52	5.29
9½	1	3.18	3.18	3.18
9	1	10.39	10.39	10.39
8	3	5.25	0.71	3.42
7	3	10.39	7.49	8.48
6½	1	13 84	13.84	13.84
6	2	15.54	3.18	9.36
5½	3	7.26	5.86	6.54
5	10	17.86	3.13	9.63

For convenience of reference, we have embodied the various amounts, representing the increase in the frictional resistance on curves, in the preceding Table No. III., and it will be noticed that they present some striking inconsistencies. It will be seen that, in the first place, there is a considerable variation between the increase in the frictional resistance obtained in different instances on curves of the same radii, the maximum being in several cases over five times—and in one instance over twelve times—the minimum value. Again, the increase of the frictional resistance on the sharper curves is, in many cases, less than that observed on those of larger radius; but this is probably due to some of the curves being so short that the resistance on them was not fairly ascertained. Indeed, Mr. Jetter expressly states in his report that many of the curves on the main line are so short that to obtain accurate results was a difficult matter, and he further says, that the results only hold good for curves of short radius which do not exceed 10 chains in length. He states that if the curve exceeds 10 chains in length the tractive force necessary at the end of the curve is much increased. At the end of a 5 chain curve, of which the length was 18 chains, and gradient 1 in 60, the tractive force required was 22 cwt., instead of 21 cwt., as given in the Table. Altogether, therefore, as we stated at the commencement of the present notice, Mr. Jetter's experiments do not afford sufficient data to enable us to form any definite rule for the increase of the resistance on curves of railways laid to the 3 ft. 6 in. gauge; but they nevertheless possess considerable interest, and they may, moreover, serve

as a nucleus, to which some of our readers may be able to add the particulars of other experiments of a similar kind.

CONCRETE STONE IN INDIA.

From "The Mechanics' Magazine."

All who are acquainted with Bombay are well aware how badly it is off for good building stone. The materials in ordinary use are trap and Porebunder stone, the former of which gives a heavy ponderous appearance to the buildings, whilst the latter is of a very perishable nature. The Coorla stone is much more durable, but it is so hard as to be almost unworkable. The stone from Hemnuggur answers well, but the cost of transit is so great as to preclude its use in all but very special cases. Hence the want of a good and cheap building material has been long and seriously felt in Bombay. That want, we are glad to find, is now supplied by the introduction of Mr. Ransome's silicious stone. The value of this invention having become known to the Secretary of State, the manufacture of the Ransome stone was forthwith directed to be carried out at the Government Works in Bombay. An establishment was organized by Mr. A. Pye-Smith, a gentleman from the inventor's works at East Greenwich, and is now in full work, producing stone on Mr. Ransome's beautiful principle. The new stone appears to afford much satisfaction, and the prospect of a material at once pleasant in color, enduring in texture, and moderate in price, is especially cheering where such serious drawbacks as those to which we have referred exist. The introduction of the stone, too, is singularly opportune, inasmuch as the Government is just commencing a series of large buildings, which it was wished to make as permanent as possible. The Ransome stone—as our readers are for the most part aware—is produced by dissolving flints in caustic soda and mixing the resulting silicate of soda with dry silicious sand and limestone powder. The paste thus formed is moulded to any desired shape, and then hardened by immersion in a solution of chloride of calcium. A shower bath of cold water drives off the chloride of sodium, and the stone, after being dried, is ready for use.

Our readers will doubtless remember, from our description of the Ransome's Stone Works at East Greenwich, that the process of saturation with the solution of chloride of calcium is accomplished by hose playing on the block, as well as by immersion. Mr. Ransome has, however, improved this part of the process, and in connection with his son, Mr. Ernest Ransome, and the well-known Mr. Bessemer, has recently obtained another patent, in which is claimed the "saturating, washing, and drying blocks or moulded pieces of artificial stone by means of a vacuum or pressure, or by both vacuum and pressure combined." And the works have now been fitted up with air pumps and other apparatus for this purpose with the most satisfactory result. In the Government Works at Bombay, Mr. Pye-Smith has introduced another very ingenious arrangement for carrying out this part of this process, consisting of an air-tight iron chest, into the upper side of which a pipe is carried from a tank placed at a considerable height above the building. The chest has a movable bottom, which is lowered by a winch and placed on a traveller. When the plate has been loaded with moulded material—the pieces being placed over vents made in the movable bottom—it is placed beneath the saturator, which somewhat resembles a diving bell. It is then screwed up in its place and well packed, the cock of the down pipe is then opened, and the chloride of calcium admitted under the pressure of a good head. It rapidly permeates the soft masses exposed to its action and converts them into durable stone, after which they are treated with water in the usual way. The only drawback the manufacture at first experienced was the difficulty of obtaining sand of the proper quality. There is no silicious sand in or near Bombay, but after several journeys, Mr. Smith found a supply at Kutch Mandive. The limestone powder is readily obtained by pounding Porebunder stone to a sufficient degree of fineness. The natural materials being thus formed, the manufactered ingredients,

such as the silicate of soda and chloride of calcium, are readily obtainable, and thus enable this important manufacture to be developed where it will prove of the greatest value. It supplies a want created by the absence of natural stone of the proper quality for building purposes, and bears striking testimony to the special merit of Mr. Ransome's invention.

ON THE DETERMINATION OF THE REAL AMOUNT OF EVAPORATION FROM THE SURFACE OF WATER.*

By MR. ROGERS FIELD, B.A., and MR. G. J. SYMONS.

The determination of the amount of evaporation from a water surface would appear at first sight a very simple problem; but that it is really by no means such, is shown by the extremely discordant results arrived at hitherto by the highest authority. To take two instances: Mr. Fletcher, M. P., F. R. S., of Tarn Bank, who is too well known as a careful observer to require that more than his name should be mentioned, and Mr. Proctor of Barry, whom Mr. Buchan describes as one of the ablest observers of the Scottish Meteorological Society. The returns from these two stations are generally in the ratio of 3 to 1; *e.g.*, in 1864, Tarn Bank, 44.23 in.; Barry, 11.09 in.; and in 1865, Tarn Bank, 47.86 in.; and Barry, 28.65 in. The high values returned by Mr. Fletcher do not result from any oversight, because a year or two since he concluded a note on evaporators in the following words: "The mean evaporation is 47 in., a quantity vastly in excess of the amount arrived at by Mr. Howard (20 in.) and Dr. Miller (30 in.), but I believe it to be more correct than either."

Some difference might be expected in the results arrived at, in consequence of the difference of locality; but such startling differences can, we believe, only be explained by the very faulty nature of the evaporators in common use.

Professor Daniell, in his "Meteorological Essays," refers to the ordinary evaporators in the following terms:

"The notion that these afford the absolute measure of the quantity of water raised into the air is absurd, for the instrument can only give the amount of evaporation from the shallow body of water in the place where it has been fixed. The conditions which modify the process vary almost *ad infinitum;* they vary on the land and on the water, they vary in the sunshine and in the shade, they vary as the land is more or less clothed with vegetation, or as the water is more or less deep. The evaporating gauge, so far from representing the circumstances of those bodies which yield the great body of vapor on the earth's surface, probably does not correspond in all essential particulars with a dozen puddles in the course of the year, and the pains which are often taken to make the results tally with those of the rain gauge, or to compare the two, are wholly misdirected." Similar condemnation has been passed by other authorities.

Professor Daniell proposes, as a substitute, two methods of calculating the amount of evaporation from observations of his dew point hygrometer; but he states that it depends on the observer's estimate of the force of the wind. We do not understand why the evaporation from the moistened surface of the hygrometer bulb does not proceed *pari passu* with that from a water surface; but, assuming it to be so, there is little probability that the force at the time of observation would be exactly the average of the day, or that it would be accurately estimated. Even Professor Daniell admits that the amount deduced by this method may exceed or fall short of the tabulated quantity to the extent of one-fourth. We venture, therefore, to consider this plan so inaccurate as to be practically useless.

In this interim note we do not propose discussing the various methods hitherto proposed, but not one of which has been generally adopted; even the best pattern of evaporator, to which we shall hereafter refer as the ordinary evaporator, is not used by one observer in twenty.

* British Association.

The great objection to nearly all evaporators hitherto used has been their diminutive size, and the consequent fact that the pint or two of water they contain has become unduly heated, and therefore the recorded evaporation has been largely in excess of what it would have been had this artificial elevation of temperature not been produced.

The only published experiments with evaporators of large size, of which we are aware, are those made some years since at Dijon and other places on the Burgundy Canal, recorded in the "Annales des Ponts et Chausées." The evaporators used in these experiments consisted of square masonry tanks about 8 ft. on each side, and 1 ft. 4 in. deep. They were lined with zinc so as to be perfectly watertight, and sunk in the ground. The amount of evaporation from these tanks was found to be less than half what was generally adopted by the best authorities as the evaporation in that district. Experiments were also made during one year with an evaporator 1 ft. square by the side of the large ones, and the evaporation in this case was found to be some 50 per cent. greater in the smaller than in the larger tank.

Professor Haughton, of Trinity College, Dublin, has published, in the Proceedings of the Royal Irish Academy, some observations on evaporation at St. Helena, by Major Phillips and Lieutenant Haughton, which, though on a smaller scale, have an important bearing on the question. These experiments were made with two different kinds of evaporators placed near each other: (1) a glass cylinder 9 in. high and 9.85 in. in diameter, fully exposed, and (2) a similar glass cylinder, placed in a large tub of water so as to have the water inside the cylinder always surrounded by water nearly the same level. In these experiments, carried on for two years, the evaporation from the exposed cylinder was found to be nearly 50 per cent. greater than that from the cylinder surrounded by water. In both the above quoted instances, the small evaporators which gave an excessive amount of evaporation were better and less liable to become unduly heated than those ordinarily in use, which may, therefore, be reasonably assumed to give still more erroneous results.

There can be no question that the most accurate method of arriving at the evaporation from a water surface is by observation on large tanks, as at Dijon; but we cannot hope that apparatus of this kind will be used save in exceptional cases, and it therefore becomes important to devise some simple arrangement which should give approximately correct results. Our own experiments having only recently been commenced, we by no means consider that we have overcome all the difficulties of the subject; but we desire to place upon record a few facts which we hope may act as incentives to further and more complete researches on this very important subject.

One fact, which partly explains the comparative neglect into which this subject has fallen, is the difficulty of measuring accurately the quantity of water abstracted, the process usually consisting in measuring the whole volume with a graduated glass; and this is also probably one reason for the small capacity of many of the evaporators, some holding only one inch deep of water.

This difficulty has been entirely obviated in our experiments by the use of a small instrument called a "hook gauge," designed sometime since by Mr. Field, as a portable instrument for purposes of hydraulic observations. The principle is borrowed from an elaborate fixed arrangement described in Francis's "Lowell Hydraulic Experiments." All other known methods of observing the height of the surface of still water are interfered with by the effects of capillary attraction, whereas this instrument owes its great precision to that phenomenon. If the point of the hook is ever so slightly raised above the water surface, it raises a small cone of water with it, which is at once rendered visible by the distortion of the reflection. If, on the other hand, the point is depressed below the water, it carries the water down with it, and forms a depression, which also causes distortion of the reflection. It is, therefore, only necessary to adjust the hook so that there shall be no distortion, and the point will then be precisely level with the surface of the water. A vernier on the slide enables the depth to be read to $\frac{1}{1000}$ in. with undeviating certainty. There is a clamped bar attached, by adjusting which, and resting it on the top of the evaporator, the zero thereof can be placed in any convenient

position, without the necessity of having a fixed point for the zero at the bottom of the vessel.

The arrangements we have adopted are shown on the diagram.

Fig. 1. represents, perhaps, one of the best forms of ordinary evaporators, many of those used even by the highest authorities (such as Luke Howard) being much more objectionable. It will be seen that it consists of a copper vessel containing about a quart of water exposed to direct and reflected heat on every side, and even on the bottom, so that if it were required to obtain the maximum temperature to which that volume of water could be raised by the solar beams, the arrangements could hardly be improved upon.

Fig. 2. represents an arrangement designed by Mr. Symons some months since, wherein the vessel, still of metal, is sunk almost wholly into the ground, so as to obviate as far as possible artificial heating.

Fig. 3. is a modification of the plan adopted by Major Phillips, at St. Helena, and already referred to. In this, the water to be measured is contained in a glass cylinder, which is placed in the centre of a much larger vessel of water, the whole being buried in the earth up to the brim of the large vessel.

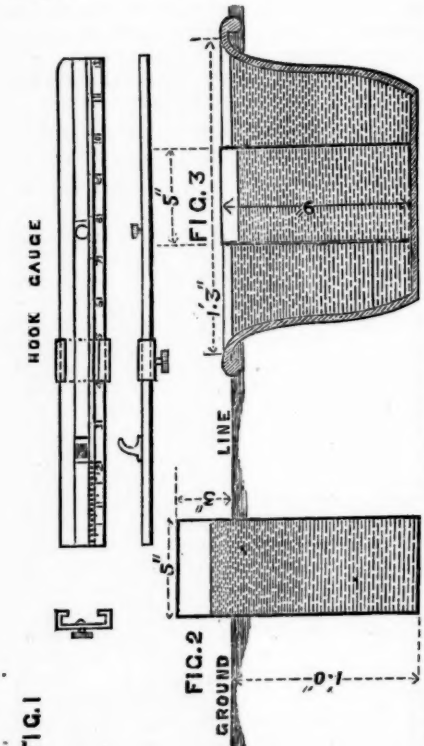
The following Table gives the detailed results of our observations :

Evaporation during part of July and August, 1869. (*Camden square, London, 111 ft. above Sea Level.*)

Date of Reading.	Evaporation in hours stated.				Evaporation in 24 hours.				Temperature of water.		
	Total hrs.	Cassellas.	Symons.	Phillips.	Cassellas.	Symons.	Phillips.	Computed from hygrometer.	Cassellas.	Symons.	Phillips.
		in.	2 in.	3 in.	1 in.	2 in.	3 in.	in.	Deg.	Deg.	Deg.
July 22, 9 A. M.	24	.18	.16	.13	.18	.16	.13	.17	82.8	77.9	74.0
" 22, 2 P. M.	5	.19	.08	.04	..	..	..	..	95.8	86.4	82.1
" 23, 9 A. M.	19	.18	.17	.14	.37	.25	.18	.30	..	..	..
" 24, 9 A. M.	24	.18	.15	.08	.18	.15	.08	.19	79.4	74.2	73 8
" 25, 9 A. M.	24	.32	.25	.20	.32	.25	.20	.18	75.0	73.8	73.2
" 25, 9 P. M.	12	20	.11	.14	..	..	..	..	83.4	79.8	76.0
" 26, 9 A. M.	12	.05	.06	.03	.25	.17	.17	.22	..	..	..
" 26, 1 P. M.	4	.12	.06	.05	..	..	..	..	..	..	..
" 26, 6 P. M.	5	.12	.08	.04	..	..	..	..	..	..	..
" 27, 9 A. M.	15	.05	.06	.08	.29	.20	.17	.17	..	..	..
" 27, 2 P. M.	5	.16	.05	.06	..	..	..	..	82.1	77.8	73.9
" 28, 9 A. M.	19	.11	.09	.06	.27	.14	.12	.10	..	..	..
" 29, 9 A. M.	24	.09	.12	.03	.09	.12	.03	.06	..	..	..
" 29, 1 P. M.	4	.04	.03	.02	..	..	..	..	79.2	72.2	71.8
" 30, 9 A. M.	20	.20	.12	.12	.24	.15	.14	.15	..	..	..
" 30, 7 P. M.	10	.11	.06	.06	..	..	..	..	..	..	..
" 31, 9 A. M.	14	.05	.04	.03	.16	.10	.09	.16	..	..	..
Aug. 1, 9 A. M.	24	.12	.12	.11	.12	.12	.11	.12	80.4	76.1	73.0
" 1, 1 P. M.	4	.08	.05	.02	..	..	..	..	..	..	..
" 1, 6 P. M.	5	.09	.07	.04	..	..	..	..	..	..	..
" 2, 9 A. M.	15	.07	.07	.08	.24	.19	.14	.14	..	..	..
" 2, 3 P. M.	6	.11	.06	.06	..	..	..	..	..	..	..
" 3, 9 A. M.	18	.02	.04	.03	.13	.10	.09	.11	..	..	..
" 4, 9 A. M.	24	.08	.06	.00	.08	.06	.00	.10	..	..	..
" 5, 9 A. M.	24	.19	.08	.10	.19	.08	.10	.16	..	..	..
" 5, 2 P. M.	5	.07	.05	.02	..	..	..	..	72.0	68.1	70.2
" 6, 9 A. M.	19	.10	.10	.12	.17	.15	.14	.21	76.4	71.3	69.5
" 6, 6 P. M.	9	.07	.06	.05	..	..	..	..	..	..	..
" 7, 9 A. M.	15	.06	.04	.03	.13	.10	.08	.21	..	..	..
" 7, 5 P. M.	8	.13	.11	.05	..	..	..	..	..	..	..
" 8, 9 A. M.	16	.06	.06	.07	.19	.17	.12	.11	..	..	..
" 9, 9 A. M.	24	.04	+.01	+.01	.04	+.01	+.01	.06	..	..	..
" 10, 9 A. M.	24	.31	.21	.16	.31	.21	.16	.15	..	..	..
" 11, 9 A. M.	24	.27	.17	.13	.27	.17	.13	.18	..	..	..
" 12, 9 A. M.	24	.15	.10	.09	.15	.10	.09	.14	..	..	..
Total	..	4.37	3.13	2.46	4.37	3.13	2.46	3.39	..	..	..
Ratio	..	..	..	..	1.78	1.27	1.00	1.38	..	..	..

It would be quite premature to draw definite conclusions from the short period of observation hitherto elapsed, but we may point out a few remarkable results.

(1.) During the three weeks ending August 12th, the total evaporation from Fig. 1 was 4.37 in.; from Fig. 2, 3.13 in.; and from Fig. 3, 2.46 in., numbers which are to each other in the ratio of 1.78, 1.27 and 1.00. Fig. 1 therefore lost 78 per cent. more water by evaporation than Fig. 3.



(2.) During the daytime the sunshine heats Figs. 1 and 2 to such an extent that the ratios of evaporation become about 250, 150, and 100.

(3.) During the night there are indications of a slight addition to Fig. 3 from condensed vapor.

(4.) It will be seen that the evaporation as computed from the hygrometer bears no regular relation to any of the others, being sometimes greater than any of them and sometimes less.

We have already pointed out that we consider the accuracy of an evaporator is largely dependent on its capabilities of retaining the temperature of the contained water at as nearly as possible that of large volumes of water, such as reservoirs, rivers, and ponds. Hitherto we have not been able to institute regular comparisons of the temperatures of the water in our experimental vessels with that of the surface of large bodies of water. Surface temperature alone is concerned, because therefrom alone can evaporation take place. On the few instances when we have done so we have found that the water in the water-surrounded glass cylinder (Phillips, Fig. 3) has been nearly identical with that of a rather shallow reservoir one acre in extent. We do not, however, consider our observations sufficiently numerous to prove this. They, however, abundantly prove the faulty nature of all ordinary evaporators, for we find the average temperature at about 2 P.M. to have been in Fig. 1, 80.7 degs.; Fig. 2, 75.8 degs.; Fig. 3, 73.8 degs.; showing an average excess of 7 degs. in the temperature of Fig. 1 over that of Fig. 3. In sunshine there is an excess of twice that amount; in fact, at times the metal becomes so hot as to scorch the hand. Before leaving the subject of temperature we may mention a singular and suggestive fact. The average excess of the temperature in the three vessels above 65 degs. is respectively 15.7 degs., 10.8 degs., and 8.8 degs.; and these values are to one another in the ratio of 1.78, 1.23, and 1.00, or nearly identical with the ratios of the amount of evaporation, viz., 1.78, 1.27, and 1.00.

We commenced this paper by placing in juxtaposition the values assigned by two high authorities in our own country, of which one was thrice the other. We can hardly more strongly advocate the claims of this question to investigation than by quoting, in conclusion, M. Vallès, the French engineer, who first called attention to the great discrepancy between the observations on the canal of Burgundy and

the data generally adopted in France by scientific men. M. Vallès says : "We do not understand how in a country like ours, and with reference to one of the most important of hydraulic data, we can rest content with only knowing that the numerical value to be attributed to this datum, so essential for a large number of engineering works, lies between two limits, one of which is double the other!"

HOW HEAT DISAPPEARS BEHIND A MOVING PISTON.

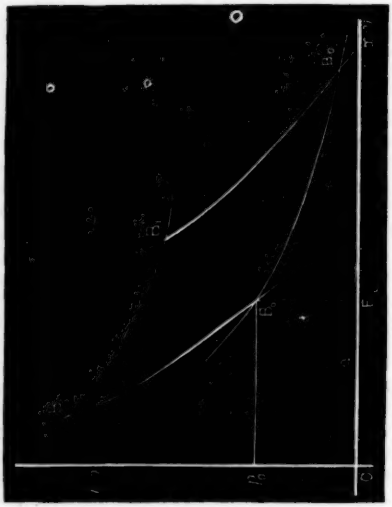
From "The Engineer."

The discovery of the age is acknowledged to be that of the thermal equivalent of mechanical work. It is possible to treat the whole theory of thermal engines—as least as far as is required for engineering purposes—without defining, or trying to define, the nature of the heat. But an hypothesis connecting facts otherwise isolated, closing up the gap preventing that thorough understanding of matters which would indicate progress in fresh directions, must be of the greatest importance, even from a merely practical point of view. By regarding heat, like sound and light, as a mode of motion, a great number of results have been discovered, which although developed—as in the book we review elsewhere—without the use of the hypothesis, could certainly not have been found out without this hypothesis. And it is only since its introduction to the world of science that a theory of heat deserving the name can be spoken of.

The ideal engine—by aid of which heat can be converted into work—merely consists of a cylinder closed at one end and embracing a piston, together inclosing a certain quantity of gas or vapor of any given unit of weight. This amount of gas has a certain volume, which we will call V_0, a certain pressure, P^0, and a certain temperature, t_0. Now, let us suppose the fluid to be compressed by an external force. Its temperature accordingly gets raised until it attains a value we will call t_1. Whilst the temperature and volume get altered by this compression, the pressure is increased according to a certain law, so that to each stage of volume and temperature there corresponds a certain pressure. This law of increase may be most plainly indicated by the accompanying diagram, first used for the purpose by Clapeyron. In this we set off on the horizontal axis, OX, the volumes ; and on the vertical axis, OY, the corresponding pressures. By well-known rules, a certain point on our diagram corresponds to certain stages of temperature, volume, and pressure of gas in our cylinder; and hence the position of the point in question changes with the volume and temperature of the gas. Supposing that B^0 is the point corresponding to the original state before the gas was compressed, then this point will move along a curve, $B_0 B_1$, during compression. During this process it is supposed that no heat was gained or lost by the cylinder. We will now imagine that it is in our power to impart heat to, or to extract heat from, the gas. This is done by an apparatus the generic term for which is heat reservoir. For instance, the fire gases of the boiler furnace form the reservoir of heat in the steam-engine. In the ideal case we are considering we may suppose a reservoir of heat is formed by a medium of a certain temperature surrounding the cylinder, and keeping the temperature of the inclosed gas at a constant height. This surrounding medium we further suppose ourselves to be at liberty to remove. We next assume that when the ideal cylinder is without its reservoir, no heat makes its way either to or from the gas ; and this we assume to have been the case with our gas during the compression mentioned above, and which left it at the temperature, t^1. We will now imagine ourselves to apply to our cylinder a reservoir of heat of the same temperature, t^1 ; and if we allow the gas again to expand, it will *not* be cooled by this expansion. The consequence is, that the pressure does not decrease so rapidly as it otherwise would. This expansion is continued during a certain time, and the reservoir of heat is then taken away, whilst the gas is still allowed to expand. As it cannot take up heat the temperature of the gas will decrease, and, consequently, the pressure will decrease more rapidly than before. As soon as the gas has cooled down to our lowest original tem-

perature, t^0, we surround the cylinder by another reservoir of heat having this temperature, t^0, and we again begin to compress the gas to the original volume. During this compression the temperature would increase if we had not applied our reservoir. But the reservoir takes up this heat, and thus our gas arrives at its original volume and its original temperature, and, consequently, its original pressure.

Returning more particularly to the diagram, we have to trace the four different stages of the process undergone by the inclosed gas. During the first stage of this process the point representing volume and pressure moved from the point B_0 to B_1. During the second stage, a similar curve, B_1 B', will be described; but as the pressure does not decrease so rapidly as it increased before, this curve will fall above the other one. During the third stage, while the temperature decreases, a curve, B'_1 B'_0, is described parallel to the first one, and during the last our



point moves back from B'_0 to the initial point B_0; thus our four curves inclose an area, B_0 B_1 B'_1 B'_0 B_0, which represents the *work done* during the whole process, exactly as the work done during a stroke of the piston is represented in an ordinary Watt's Indicator diagram.

During the second part of the process, whilst the reservoir of the high temperature, t_1, was applied, heat was taken up into the cylinder, and during the last process the other reservoirs of the low temperature, t_0, took up heat from the gas. During the process heat passes into the cylinders from a hot reservoir, and heat flows into one of a lower temperature.

This was already known to Clapeyron, the inventor, in 1834, of this diagram; but the original indication that heat can only do work by flowing from a hotter body to a cooler one is due to S. Carnot, the son of the great French Minister of War and mathematician of that name. It is clear, for instance, that it would be impossible to work an engine in an atmosphere having the temperature of the steam with which it is supplied. In such a case our diagram would shrink up to a single line, inclosing no area at all, and therefore indicating no work. If we suppose an atmosphere hotter than the steam, we should have to do external work to get the engine into motion; the steam would have to be pumped out of the boiler into the atmosphere. In the ideal engine we have supposed, it is possible by doing work to extract heat out of the cooler reservoir and to impart it to the hotter one.

According to Clapeyron, *no* heat was transformed in the engine whilst doing work; and accordingly he supposed that the quantities of heat taken up and given off during the cycle of its progress through the engine were equal. But in reality heat actually disappears in producing work, it actually disappears behind the moving piston of a steam-engine; a physically demonstrable fact that cannot be at all explained on the caloric theory that heat is a fluid. It was therefore necessary to find out another hypothesis more suited to the facts. In 1842, Dr. Mayer, of Heilbronn, clearly pointed out, not only that heat is actually lost, but that always the same amount of heat disappears in doing a given amount of work, or that there exists a mechanical equivalent of heat. The same thing was done in the course of the following year by A. Colding, an engineer of Copenhagen. At the same time Dr. Joule, of Manchester, independently of both, began his experiments on this subject. By the hypothesis linking together a great number of natural phenomena, the *vis viva* of the molecules, which is heat, is transferred into *vis viva*, or work

accumulated in the piston, and visibly appearing in its motion.

According to the doctrine of the thermal equivalent of work, the amount of heat disappeared in our engine depends only on the work done; but it is another question, whether the amount of heat which flows uselessly into the cooler reservoir is always the same. And here the mechanical theory of heat steps in and shows that this depends upon the temperature of the two reservoirs. It diminishes with the temperature of the cooler reservoir, and the amount which passes into the cooler body can never be zero, except in case that this cooler body has the exceedingly low temperature of 273° Cent. below freezing point. These figures appear a little paradoxical, but are easily explained. The amount of *vis viva* of the molecules determines the temperature; and when this *vis viva* is zero there is no heat. The German Professor Clausius has demonstrated that at this temperature—of course unapproached and unapproachable in this universe—there can be no motion of the particles, and therefore no heat. Clausius consequently calls this temperature the absolute zero; and in the mechanical theory of heat the scale of the thermometer, so to speak, is counted from this zero. If we could cool down the temperature of our reservoir of heat to this point, our engine could convert all heat of a hotter reservoir into work. Comparing our ideal engine with the common steam-engine, we find that in both cases we have a cylinder; but in the practical instance we have the steam passing, as the vehicle of the heat, through the cylinder, whilst in the ideal thermal engine we had the heat by itself. In the steam-engine our two reservoirs of heat are the furnace and the atmosphere, or a special condenser, which takes up the heat flowing out of the engine; the ordinary indicator diagram being accordingly different to Clapeyron's theoretical diagram. The inlet of the steam at the first moment corresponds to the first stage of the process of the ideal engine, represented by the line $B_1 B'^0$, but becoming an almost vertical line in the steam-engine. The straight horizontal line corresponds to the line $B_1 B'^1$; and the line during expansion corresponds to $B'_1 B'^0$. The exhaust of the steam would give the curve $B'^0 B^0$; and it is clear, as all is going on continuously in the steam-engine, we cannot have the sharp corners of the Clapeyron curve. The heat passing, together with the steam, into the cylinders, may, with regard to its mechanical effect, be divided into two parts—into the heat converted into actual work, and into that which, even theoretically, necessarily must pass into the condenser or atmosphere; without counting, of course, the numerous practical losses by induction, condensation on chilled surfaces, conduction, and others. The proportion of the loss of this second part to the whole becomes less by an increase of the difference of temperature between the boiler and the atmosphere. In the condenser we regain some of the work formerly used to convert the water into steam. Hence a steam-engine will work all the more economically, as regards the expenditure of coal, the higher the temperature of the steam, and the lower the temperature at which it leaves the cylinders.

The general principles illustrated by the diagram are, therefore, first, that heat can only work by passing from a hotter, through an engine, to a cooler body; and, secondly, that during this passage one portion of the heat is converted into work, whilst another portion actually passes over into the cooler body.

The artillery experiments at Finspong, in Sweden, have now been completed, and the Danish Minister of War, M. Raasloff, has returned to Copenhagen. The new 11½ in. gun, which is made entirely of Swedish iron, has met with general approval both among Swedish and Danish artillerists. It was fired from a distance of 580 ft. at a target made of six plates of iron, each 2 in. thick, and backed with strong wooden beams. About 20 yards behind it was a wooden target 2 ft. thick, leaning against an embankment of gravel. The conical projectile of the gun, weighing 150 lbs., pierced both targets and buried itself to a depth of 8 ft. in the embankment.

Sir John Herschel calculates that the great pyramid weighs 12,760,000,000 lbs. Lyall gives a larger estimate of 6,000,000 tons. According to Perring, the present quantity of masonry is 6,316-000 tons, or 82,110,000 cubic ft.

ENGINEERING PROGRESS.

From "The Practical Mechanic's Journal."

An Abstract of an address delivered before the Mechanical Science Section of the British Association, by Mr. G. W. SIEMENS, President of the Section.

In viewing the latest achievements of engineering science, two works strike the imagination chiefly by their exceeding magnitude, and by the influence they are likely to exercise upon the traffic of the world. The first of these is the great Pacific Railway, which, in passing through vast regions hitherto inaccessible to civilized man, and over formidable mountain chains, joins California with the Atlantic States of the great American Republic. The second is the Suez shipping canal, which, notwithstanding adverse prognostications and serious difficulties, will be opened very shortly to the commerce of the world. These works must greatly extend the range of commercial enterprise in the North Pacific and the Indian Seas. The new water-way to India will, owing to the difficult navigation of the Red Sea, be in effect only available for ships propelled by steam, and will give a stimulus to that branch of engineering. Telegraph communication with America has been rendered more secure against interruption by the successful submersion of the French Transatlantic cable. On the other hand, telegraphic communication with India still remains in a very unsatisfactory condition, owing to imperfect lines and divided administration. To supply a remedy for this public evil, the Indo-European Telegraph Company will shortly open its special lines for Indian correspondence. In Northern Russia the construction of a land line is far advanced, to connect St. Petersburg with the mouth of the Amoor river; on the completion of which, only a submarine link between the Amoor and San Francisco will be wanting to complete the telegraphic girdle round the earth. With these great highways of speech once established, a network of submarine and aerial wires will soon follow, to bind all inhabited portions of our globe together into a closer community of interests, which, if followed up by steam communication by land and by sea, will open out a great and meritorious field for the activity of the civil and mechanical engineer. But while great works have to be carried out in distant parts, still more remains to be accomplished nearer home. The railway of to-day has not only taken the place of high roads and canals for the transmission of goods and passengers between our great centres of industry and population, but is already superseding by-roads leading to places of inferior importance; it competes with the mule in carrying minerals over mountain passes, and with the omnibus in our great cities. If a river cannot be spanned by a bridge without hindering navigation, a tunnel is forthwith in contemplation; or, if that should not be practicable, the transit of trains is yet accomplished by the establishment of a large steam ferry. It is one of the questions of the day to decide by which plan the British Channel should be crossed, to relieve the unfortunate traveller to the continent of the exceeding discomfort and delay inseparable from the existing most imperfect arrangements. Considering that this question has now been taken up by some of our leading engineers, and is also entertained by the two interested Governments, we may look forward to its speedy and satisfactory solution. So long as the attention of railway engineers was confined to the construction of main lines, it was necessary for them to provide for a heavy traffic and high speeds, and these desiderata are best met by a level permanent way, by easy curves and heavy rails of the strongest possible materials, namely, cast-steel; but in extending the system to the corners of the earth, cheapness of construction and maintenance, for a moderate speed and a moderate amount of traffic, becomes a matter of necessity. Instead of plunging through hill and mountain, and of crossing and recrossing rivers by a series of monumental works, the modern railway passes in zigzag up the steep incline, and conforms to the windings of the narrow gorge; it can only be worked by light rolling stock of flexible construction, furnished with increased power of adhesion and great brake power. Yet by the aid of the electric telegraph, in regulating the progress of each train, the number of trains may be so increased as to produce, nevertheless, a large aggregate of traffic; and

it is held by some that our trunk lines even would be worked more advantageously by light rolling stock. The brake power on several of the French and Spanish railways has been greatly increased by an ingenious arrangement, conceived by M. Le Chatelier, of applying what has been termed "contre vapeur" to the engine, converting it for the time being into a pump, forcing steam and water into the boiler. While the extension of communication occupies the attention of, perhaps, the greater number of our engineers, others are engaged upon weapons of offensive and defensive warfare. We have scarcely recovered our wonder at the terrific destruction dealt by the Armstrong gun, the Whitworth bolt, or the steel barrel consolidated under Krupp's gigantic steam-hammer, when we hear of a shield of such solidity and toughness as to bid defiance to them all. A larger gun or a harder bolt by Palliser or Grüsen is the successful answer to this challenge; when, again, defensive plating, of greater tenacity to absorb the power residing in the shot, or of such imposing weight and hardness combined as to resist the projectile absolutely (causing it to be broken up by the force residing within itself), is brought forward. The ram of war, with heavy iron sides, which a few years since was thought the most formidable, as it certainly was the most costly, weapon ever devised, is already being superseded by vessels of the *Captain* type, as designed by Captain Coles, and ably carried out by Laird Brothers, with turrets (armed with guns of gigantic power) that resist the heaviest firing, both on account of their extraordinary thickness and of the angular direction in which the shot is likely to strike. By an ingenious device, Captain Moncrieff lowers his gun upon its rocking carriage after firing, and thereby does away with embrasures (the weak places in protecting works), while at the same time he gains the advantage of reloading his gun in comparative safety. It is presumed that in thus raising formidable engines of offensive and defensive warfare, the civilized nations of the earth will pause before putting them into earnes operation; but if they should do so, it is consolatory to think that they could not work them for long without effecting the total exhaustion of their treasuries, already drained to the utmost in their construction.

While science and mechanical skill combine to produce these wondrous results, the germs of further and still greater achievements are matured in our mechanical workshops, in our forges, and in our metallurgical smelting works; it is there that the materials of construction are prepared, refined, and put into such forms as to render greater and still greater ends attainable. Here a great revolution of our constructive art has been prepared by the production, in large quantities and at moderate cost, of a material of more than twice the strength of iron, which, instead of being fibrous, has its full strength in every direction, and which can be modulated to every degree of ductility, approaching the hardness of the diamond on the one hand, and the proverbial toughness of leather on the other. To call this material cast-steel seems to attribute to it brittleness and uncertainty of temper, which, however, are by no means its necessary characteristics. This new material, as prepared for constructive purposes, may indeed be both hard and tough, as is illustrated by the hard steel rope that has so materially contributed to the practical success of steam-ploughing. Machinery steel has gradually come into use since about 1850, when Krupp, of Essen, commenced to supply large ingots that were shaped into railway tyres, axles, cannon, etc., by melting steel in halls containing hundreds of melting crucibles. The Bessemer process, in dispensing with the process of puddling, and in utilizing the carbon contained in the pig-iron, to effect the fusion of the final metal, has given a vast extension to the application of cast-steel for railway bars, tyres, boiler-plates, etc. This process, however, is limited in its application to superior brands of pig-iron, containing much carbon and no sulphur or phosphorus, which latter impurities are so destructive to the quality of steel. The puddling process has still, unless the process of decarburization of Mr. Heaton takes its place, to be resorted to, to purify these inferior pig-irons, which constitute the bulk of our productions; and the puddled iron cannot be brought to the condition of cast-steel except through the process of fusion. This is accomplished successfully in masses of from 3 to 5 tons on the open bed of a regenerative furnace at the Landore Siemens Steel Works, and at

other places. At the same works cast-steel is also produced, to a limited extent as yet, from iron ore, which, being operated upon in large masses, is reduced to the metallic state and liquefied by the aid of a certain proportion of pig metal. The regenerative gas furnace—the application of which to glass-houses, to forges, etc., has made considerable progress—is unquestionably well suited for this operation, because it combines an intensity of heat, limited only by the point of fusion by the most refractory material, with extreme mildness of draught and chemical neutrality of flame. These and other processes of recent origin tend toward the production, at a comparatively cheap rate, of a very high-class material that must shortly supersede iron for almost all structural purposes. As yet engineers hesitate, and very properly so, to construct their bridges, their vessels, and their rolling stock of the material produced by these processes, because no exhaustive experiments have been published as yet fixing the limit to which they may safely be loaded in extension, in compression, and in torsion, and because as yet no sufficient information has been obtained regarding the tests by which their quality can best be ascertained. This great want is in a fair way of being supplied by the experimental researches that have been carried on for some time at her Majesty's dockyards at Woolwich, under a committee appointed for that purpose by the Institution of Civil Engineers. The president had also the pleasure to announce an elaborate report by Mr. Wm. Fairbairn on this subject. In the meantime excellent service has been rendered by Mr. Kirkaldy in giving us, in a perfectly reliable manner, the resisting power and ductility of any sample of material which we wish to submit to his tests. The results of Mr. Whitworth's experiments, tending to render the hammer and the rolls obsolete by forcing cast-steel, while in a semi-fluid state, into strong iron moulds by hydraulic pressure, are looked upon with great interest. But, assuming that the new building material has been reduced to the utmost degree of uniformity and cheapness, and that its limits of strength are fully ascertained, there remains still the task for the civil and mechanical engineer to prepare designs suitable for the development of its peculiar qualities. If in constructing a girder, for example, a design were to be adopted that had been worked out for iron, and if all the scantlings were simply reduced in the inverse proportion of the absolute and relative strength of the new material, as compared with iron, such a girder would assuredly collapse when the test weight was applied, for the simple reason that the reduced sectional area of each part, in proportion to its length, would be insufficient to give stiffness. You might as well almost take a design for a wooden structure, and carry it out in iron by simply reducing the section of each part. The advantages of using the stronger material become most apparent if applied, for instance, to large bridges, where the principal strain upon each part is produced by the weight of the structure itself; for, supposing that the new material can be safely weighted to double the bearing strain of iron, and that the weight of the structure were reduced by one-half accordingly, there would still remain a large excess of available strength in consequence of the reduced total weight, and this would justify a further reduction of the amount of the material employed. In constructing works in foreign parts the reduced cost of carriage furnishes also a powerful argument in favor of the stronger material, although its first cost per ton might largely exceed that of iron.

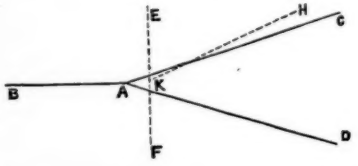
The inquiries of the Royal Coal Commission into the extent and management of the coal-fields appear to be reassuring as regards the danger of their becoming soon exhausted; nevertheless, the importance of economizing these precious deposits in the production of steam power, in metallurgical operations, and in domestic use, can hardly be overestimated. The calorific power residing in a pound of coal of a given analysis can now be accurately expressed in units of heat, which again are represented by equivalent units of force or of chemical action; therefore, if we ascertain the consumption of coal of a steam-engine, or of a furnace employed in metallurgical operations, we are able to tell by the light of physical science what proportion of the heat of combustion is utilized and what proportion is lost. Having arrived at this point we can also trace the channels through which loss takes place, and in diminishing these by judi-

cious improvement we shall more and more approach those standards of ultimate perfection which we can never reach, but which we should, nevertheless, keep steadfastly before our eyes. Thus, a pound of ordinary coal is capable of producing 12,000 Fahrenheit units of heat, which equal 2,240,000 foot-pounds, or units of force; whereas the very best performances of our pumping-engines do not exceed the limit of 1,000,000 foot-pounds of force per pound of coal consumed. In like manner, 1 lb. of coal should be capable of heating 33 lbs. of iron to the welding point of (say) 3,000 deg. Fahr., whereas, in an ordinary furnance, not 2 lbs. of iron are so heated with 1 lb. of coal. These figures serve to show the great field for further improvement that lies yet before us. Although heat may be said to be the moving principle by which all things in nature are accomplished, an excess of it is not only hurtful to some of our processes, such as brewing, and destructive to our nutriments, but to those living in hot climates or sitting in crowded rooms an excess of temperature is fully as great a source of discomfort as excessive cold can be. Why, then, he asked, should we not resort to refrigeration in summer as well as to calorification in winter, if it can be shown that the one can be done at nearly the same cost as the other?

THE BRIDGE OF COURCELLES.

From "The Building News."

Had it not been for the introduction of iron, and its extensive application to railway bridge building, it would have been almost impossible to have manœuvred the modern lines in the tortuous manner many of their routes exhibit. There is a limit to the angle of skew at which an arch of brickwork or masonry may be constructed, but there is practically no limit to the obliquity that may attend an horizontal girder. The latter principle is therefore



the one peculiarly applicable to instances where the angle between the roads above and below the bridge depart much from that of ninety degrees, and that invariably employed by engineers. With the exception of the bridge over La Place de l'Europe, there is not one of the numerous structures of that nature erected in Paris, which has so sharp an angle of skew as the one recently put up at Courcelles, a station on the central railway of the French metropolis. An inspection of the diagram will give a very good idea of the difficulties that M. Clerc, the engineer to the line, had to contend against. The thick lines A D and A C represent two railways which meet at the point of convergence, A; E F and H K show the streets which necessitated the bridge in question; the former being the Rue Brémontier, and the latter the Boulevard Péreire. As a consequence of this convergence of the two roads, it is evident that one bridge had to serve as an abutment for the other. The whole superficial area of the superstructure was not less than three thousand square yards. The general plan adopted was as follows: A triangular pier of masonry was built in the fork where the two railways meet, and two abutments were also erected in the direction of A C and A D. Upon this pier and these abutments was carried the Rue Brémontier, which is 65 ft. in width. The Boulevard Péreire was supported by a bridge, the girders of which rested at one end upon the two abutments already described, and at the other upon the face girder of the bridge, carrying the Rue Brémontier. There are five main girders in this structure, consisting of two outside or face girders, and three inside or intermediate ones. The minimum height of any part of the superstructure above the rails is fixed by the Government at 15.75 feet, and does not not depend upon the height of the funnels of the locomotive, as with us. The reason why a general limit should be imposed, is not quite clear. So long as the bridge is high enough to clear the locomotive un-

derneath, there is not the slightest necessity for making it any higher. It is different when a railway goes over a road. Then it is indispensable to fix some general minimum heading, which, on English lines, is put at 15 ft. for a public road, and 12 ft. for a farm or occupation road.

One of the chief difficulties M. Clerc and his colleague, M. Marin, had to contend against, was the difference of level in the two thoroughfares that had to be taken over the line. This is one of those vexatious points that occasionally arise in construction, and annoy the engineer beyond measure; not so much on account of their presenting any real constructive or scientific difficulty, but from the fact that they render absolutely impossible any attempt at an ornamental or æsthetical design. It is vain to endeavor to combine beauty with abstract utilitarian requirements. The main girders in the Rue Brémontier bridge, which are 243 ft. over all, are not of the same height throughout their whole length, which, but for the cause already mentioned, they would have been. For the same reason the cross girders are much heavier than they need otherwise have been, and the whole effect of the unavoidable condition imposed upon the engineers has been to deprive the structure of that lightness and elegance which under different circumstances would have undoubtedly belonged to it. All the girders, outside as well as inside, are of the lattice type, thus demonstrating that the economy of this principle of bridge construction is understood in France as well as by our own engineers. The diagonal bars in compression, usually termed struts, are of the ordinary channel section, the form of all others the best adapted to resist strains of that nature. Those in tension, or the ties, are plain rectangular bars, which suffice for all purposes where strains of only a tensile character are developed. It is evident that among ourselves the old system of carrying the roadway upon arches of brick, turned between the lower flanges of the girders, is fast becoming obsolete, and Mallet's buckled plates are being substituted as the new *regime*. For strength and lightness there is nothing to compare with them, nor can there be any doubt about their ultimate economy. When that term, however, is used to signify mere saving of money in first cost, they cannot be included under its signification. Hollow brick arches, which are a great deal lighter than solid ones, are still very much patronized by French engineers, and they constitute in the bridge under notice the means for carrying the roadway. Over these is laid concrete, and a coating of asphalte makes everything water-tight.

In order to provide for the expansion and contraction of the main girders, they are free to move on the abutments on cast-iron slides, while they are fastened down to the triangular pier of masonry. Rollers are also placed on the top of the intermediate columns which divide the whole length into smaller spans, upon which they can move freely. The erection of the bridge was accomplished in a double manner. Part of it was put up by the aid of a temporary bridge and scaffolding, and the other part was all riveted together on the adjoining ground, and pushed into its place on rollers. This latter is a method that has been frequently adopted in situations such as a deep ravine, where it is impossible to erect any scaffolding or temporary work. At the same time, it is a serious question whether the force necessary to propel so large a mass of ironwork, may not strain in some degree the structure under its influence. The whole of the iron-work of the bridge of Courcelles was contracted for by the firm of Gouin & Co. The price for the wrought-iron was at the rate of 53 francs per hundred kilogrammes, and for the cast, 25 francs. Reducing to English measures and units, we have the wrought iron at £21 10s. per ton, and the cast at £10 3s.

THE Russian newspapers announce that experiments will shortly be made on the Neva with a new invention for propelling ships without using either paddles or screws. The author of this invention is M. Liwczak, an Austrian by birth, who some time ago invented a flying machine propelled by steam, and subsequently became the editor of a Panslavist paper published in Vienna.

THE Amazon drains an area of 2,500,000 sq. miles; its mouth is 96 miles wide, and it is navigable 2,200 miles from its mouth.

REPORT ON THE EXPERIMENTS MADE IN PARIS ON THE APPLICATION AND PURIFICATION OF SEWAGE.

From "The Engineer."

An elaborate report on the experiments made at Clichy, near Paris, on the utilization and purification of sewage, has been drawn up by M. Mille and M. Claye, the engineers charged with the management of these important experiments.

These experiments have been entered upon with a full knowledge of what has been done in other countries, and especially in Great Britain, several visits having been made by French engineers and chemists to England, who have evidently studied the subject with their usual acuteness.

The great collector which now receives the waste waters of 66,000 houses, inhabited by nearly two millions of souls, as well as that of a large number of factories, the rainfall and the washings of the public ways, but not the solid excremental matter, empties itself into the Seine at a considerable distance below the city. The experimental establishment at Clichy is situated at about 400 yards from the mouth of the great trunk collector, where the sewer presents the best conditions for a uniform flow, and here the quantity of liquid passing at every hour of the day is carefully gauged by means of floats and staffs. Once a fortnight a brigade of men pass twenty-four hours in the sewer, taking observations every hour. At other times this is only performed twice in the day, namely, at ten in the morning and four in the afternoon; and these observations are afterwards carefully worked out until the results are brought to tally with each other.

It should have been stated above that the series of experiments referred to is now completed, having occupied two years, and an expenditure of nearly £9,000.

To recur to the operations for ascertaining the quantity of liquid passing the sewer, and the rate at which it flows, it may be mentioned that 2,900 observations were made in a period of twelve months, and that the curves of variation are carefully mapped out hourly, daily, and monthly. The general results are as follow: Average, with a liquid depth of one metre, two and one-fifth cubic metres or tons per second, flowing at the rate of 90 centimetres. The maximum result given is that which occurred after a heavy fall of rain, when the volume of liquid reached 45 tons, and the speed 10 metres per second. The total volume passing through the sewer during the year 1868 is stated at 70,000,000 tons; but this only included the sewage of the right bank of the Seine, the connection with the other side of the town not having been made by means of the great siphon of the Seine until November in that year.

The comparison between the quantity of water distributed in Paris, added to the rainfall and the amount passing through the sewer, is important. Average daily district, 213,689 tons; rainfall, 114,726. Total, 328,415 tons. Average debit of sewer, 190,905, equal to 58 per cent. But here, again, it must be observed the siphon for the left bank was not yet in action. The reporters add, however, that during the cold months the quantity of water carried into the Seine by ordinary channels and lost by infiltration, and especially by evaporation, amounts to about one-third of the whole amount; while during the great heats the proportions are reversed, and only one-third passes into the collector.

In the Seine, as in the Thames, immense deposits are formed at the mouth of the sewer, and dredging machines are frequently at work to break down this bar; while the right bank of the river is bordered by a bed of mud covered with organic matter. What is the amount of this solid matter at present thrown into the Seine, and what is its value as manure? This is the problem which the experiments at Clichy solve theoretically.

In the laboratory or on the grounds the agent employed is alum. The sulphate of alumina is decomposed by the sewage liquid, and converted into a gelatinous substance which carries down with it by its weight the solid matter in suspension, and leaves the water in a few hours almost limpid. This method is borrowed from the Egyptians, Chinese, and other Eastern nations, who use alum to purify turgid water.

Every day two litres of the sewage

water was taken at different times of the day, so as to obtain a fair average result, and the precipitate made by a dose of alum, in the proportion of 2 to 10,000 of the liquid to be acted upon. The precipitate, being collected on the filter and dried, was submitted to chemical analysis.

The result obtained, in the first place, is, that each ton of sewage contains more than 6 lbs. of foreign matter, one-third more of which is in a state of dissolution, and the remaining two-thirds in suspension. This foreign matter is thus given in the report:—Nitrogen, 0.037 kilos. per ton; phosphoric acid, 0.015 kilos. per ton; potash, 0.030 kilos. per ton; soda, 0.101 kilos.; organic matter, 0.729 kilos.; mineral matter, 1.984 kilos. Total, 3.002 kilos.

The sand and other inert matter it will be seen amounts to very nearly two-thirds of the total amount. The precipitate produced by the alum contains nearly half the nitrogen and phosphoric acid and the greater portion of the organic matter, the remainder being left in the purified water, which consequently still retains about half the azote and phosphoric acid, the soluble alkalis, a great part of the lime, and the remainder of the organic matter.

The following is the estimate drawn from the analyses referred to:—Sewage, at 10 cents per ton, 7,000,000f. per annum; or precipitate, at 20f. per ton, 4,000,000f. per annum; clarified liquid, at 6 cents per ton, 3,000,000f. per annum—theoretically, £280,000 thrown annually into the Seine.

As regards the effect on the river the reporters say: As the 70,000,000 tons of sewage annually thrown into the Seine contain 2 kilos. of solid matter per ton, the obstruction, which must constantly be dredged away amounts to 140,000 tons per annum; the bank of mud when uncovered is of a gray tinge, and contains a quantity of straw and other waste matter. In summer fermentation takes place, and the feculent mass poisons the air with its noxious exhalations. This mud is found on analysis to contain all the elements of the precipitate, obtained by means of alum, with the single exception of the phosphoric acid, but in proportion to the distance from the month of the sewer it becomes impoverished as regards nitrogen and organic matter, and finally becomes a mere mineral mass; but, add the reporters, *all that is missing swims in the stream and constitutes the pollution of the river.*

A note relative to the temperature of the sewage deserves notice. During the cold weather of January, when the Seine was frozen, the water in the sewers continued to run with a temperature of about 40 deg., sufficient to melt ice; during the great heat of July, when the Seine was above 75 deg., the sewage was under 68 deg. The contents of the sewer then escapes extreme variations of temperature, and the sewage would warm the land in winter and cool it in the summer.

The experimental works at Clichy were arranged to act upon 500 tons of sewage per day, and the total amount taken out of the sewer during the twelve months ending in November, 1868, was 133,164 tons, or about one four-hundreth part of the whole sewage, or nearly the same quantity as was applied at the Barking farm.

In the direct application of the sewage to the experimental crops, the liquid was carried around the field by means of channels measuring about 16 in. in breadth, and from 4 in. to 8 in. in depth, and forming a continuous line of more than 1,000 yards in length. The ground was divided into beds, or furrows, varying from 24 in. to 40 in. in width, and the trenches between the beds varied from 6 in. to 12 in. in depth, and from 20 m. to 25 m. in length. The sewage was by this means carried to the roots of the plants, and never approached their leaves. In the winter, when the ground was cleared, it was prepared in the following manner: The surface was roughly levelled, and the sewage directed over the surface of the ground, which absorbed the liquid, while the matter in suspension formed a deposit upon the surface.

The alum preferred for the operation of purification was obtained by treating kaolin with sulphuric acid, delivered in the form of a solution, having a density of 1.074. Its composition is stated as follows: Alumina, 2 per cent.; sulphuric acid, 5.40 per cent.; iron, a trace; water, 92.60; and its cost, just one shilling per cwt. The quantity employed was rather less than one-half litre per ton of sewage to be purified, and the cost little more than one-tenth of a penny. Many other purifying agents have been tried at the works, but none have been found to possess the necessary qualities, combined with cheapness, to the same extent as the

sulphate of alumina. The purification pits are thirty metres long by two metres in depth, with sloping sides, giving an average width of eight metres. Each of these purifiers is capable of yielding from fifty to sixty tons per hour, with an expenditure of ten kilogrammes of the solution. Practically it appears, according to the report, that each ton of precipitate, in a perfectly dry state, requires an expenditure of 7s. 6d. for alum.

The effects of the sewage water as applied to grass, vegetables, and flowers, are carefully tabulated, and place its value as a manure beyond doubt. This, however, is no new result, and our space will not allow of our giving unnecessary details. Some special experiments, however, have considerable importance; for instance, one-half of a piece of grass was cultivated with the aid of purified sewage only, that is to say, the water from which the precipitate had been obtained by means of alum; while the other received in addition a dressing of the precipitate, about an inch in thickness, while another piece by its side was treated with a thin dressing of the precipitate and without any sewage or other water. The former yielded a crop equal to $37\frac{3}{4}$ tons per hectare, and the un-irrigated part only produced at the rate of $4\frac{1}{2}$ tons, while the soil in the former case was found on analysis to be considerably richer than it was previous to the experiment. The soil, it should be mentioned, was a poor virgin subsoil, wanting in nitrogeneous and phosphoric elements. In another instance two equal portions, each of 715 square metres, of a patch of wheat, were cultivated—one with two-and-a-half tons of common manure, the other with the same weight of the precipitated matter of the sewer water; the produce in grain was the same in each case, namely, thirty hectolitres, and of precisely the same value; but the value of the straw was rather more on the side of the farm manure, namely, 281 f. against 225 f. This experiment is being repeated this year in order to ascertain whether there is any difference in the condition of the soil in the two cases.

With respect to the success obtained in these experimental essays, we have a report of a commission composed of the president and many of the most active members of the Imperial Society of Horticulture, of France. The commission pronounces the experiments completely successful, especially in the case of cardoons, salad, including endive, pumpkins, melons, beetroot, maize, and potatoes.

The experiments at Clichy have now come to a close, but pipes have been laid down to carry the sewage across the river, where a large tract of ground on the plain of Gennevilliers will allow of the essays being continued on a broader scale. Some few of the experiments referred to above, were tried by farmers and others on their own grounds to aid the commission, and similar assistance is being given by farmers and market gardeners this year.

In their *resumé*, the reporters say: "These 190,000 tons—which are thrown into the Seine every twenty-four hours, and which will presently be increased—can they be turned from the river? Can they be utilized? Yes, by adopting the natural means of irrigation; and, during the dead season, by purification by means of alum. The result, which will be obtained without danger to health, will be to convert into market gardens the sandy plains around Paris, which are now occupied by grain crops. The cost—which must be set down at two to three centimes per ton for distribution and purification together—will be a heavy one for the city, if left to bear it alone. It is for the cultivators to understand that they can afford to pay for sewage, precipitate, and purified water. It is necessary, therefore, to create customers. Before going further, the municipal authorities have directed that the attempt should be made, and this is the object which we now have in view."

The scientific and at the same time practical manner in which the experimental work has been carried on, reflects the highest credit upon the engineers to whom it has been intrusted. They have fully succeeded in showing the utility and economy of the direct application of sewage; they have adopted perhaps the best agent of purification in an economical sense, they have shown the great value of the precipitate as a manure, and the lesser value of the purified water; but they have not yet, unfortunately, shown that purification can be made a paying process, and the general opinion is that customers will not be found to pay for the product a sum equal to the cost of the operation. But it must be remembered that these experi-

ments refer to sewage much less rich than that of London. The following is the amount of foreign matter found in a ton of the water of the Paris sewers: Nitrogen, 0.037 kilos.; phosphoric acid, 0.015 kilos.; potash, 0.030 kilos.; soda, 0.101 kilos.; organic matter, 0.729 kilos.; mineral matter, 1.802; total kilos., 2.804, or nearly 6 lbs., of which only one-third consists of fertilizing elements. If our neighbors can find a paying market for the precipitated matter from such sewage, they will have performed one of the most useful victories which practical science has yet achieved, and we heartily wish them success.

LA CIOTAT.

From "The Railway News."

Creusot is not the only great manufacturing establishment in France which exhibits manufacturing skill of the highest order, and which also has thought fit to provide systematic training for the skilled workmen who give to the works they exhibit the scientific perfection and high finish which have astonished the English jurors and taken by surprise the large mass of the British public, who had hitherto believed in our own unapproachable supremacy in the highest branches of skilled manufacture. There is another manufacturing establishment besides Creusot which exhibits large marine engines and models of steamships. La Ciotat is a small town in the south of France, containing 10,000 inhabitants, who are almost all families of workmen employed in the shipbuilding yard and the engineering establishment of the company called Les Messageries Imperiales. What this company does, what it exhibits, and what teaching it provides for its people, is in many ways worthy of our consideration.

This company is the proprietor of a large fleet of Mediterranean steamships. Much of the Mediterranean steam trade that used to be carried on in English steamships with English engines is now done with French engines and French steamships built at La Ciotat. It is not more than fifteen years since that company obtained possession of La Ciotat, and made contracts for the French Government in the Mediterranean, and it has now succeeded in driving most of the English ships, engines, and companies who used them, out of the coasting trade of the Mediterranean. Of these ships and engines there are some excellent models in the marine department of the French Exhibition; they are obviously the work of high education and perfect organization. Perhaps, however, we may accept the fact of La Ciotat's having driven us out of so large a field of profitable enterprise, as the highest testimony that can be borne to the excellence of the administration there.

But the company has done another thing still more worthy of notice, especially as it comes still closer home to us. This company is the great rival to our own great steam navigation company, the Peninsular and Oriental. A few years ago the Messageries Imperiales established a rival line of mail steamers, to carry European mails by Marseilles, Alexandria, Suez, and the Red Sea, to India and China. We at first disregarded, perhaps despised, this daring attempt to place steamships and engines of French manufacture on a large oceanic line which we had always deemed exclusively our own. But it turned out that the French company had so well thought out their plans, so well proportioned their ships and engines to the work to be done, and so finely organized their executive, that from the moment they started till now their line has been distinguished above ours by greater punctuality and fewer accidents; indeed, the work is done so well that in our own Parliament last session the representative of the Treasury told the House of Commons that England would best consult the interes. of its territories in the East by confiding part of our mail service to the company of La Ciotat, instead of trusting them exclusively to the ships of our own Peninsular and Oriental Company.

The details of the education which this company provides for its people are remarkable. Its chief superintendents are engineers and naval architects who have received the highest professional education that France provides. Its ships are

designed by men who have first passed through the Ecole Polytechnique, and afterwards graduated at the Imperial School of Naval Architecture. Its chief engineers have in like manner graduated in science at the Ecole Polytechnique, and completed their studies in the school of marine engineering, or are pupils of the central school of manufactures at Paris. The next class under these have also been educated at the central school of arts and manufactures. It is no wonder, that with such men as these at the head of the workshops, the want of educated workmen should speedily have been felt. The company employs 2,500 workmen and apprentices, who, with their families, form a population of 6,000 out of the 10,000 inhabitants of the town; and they provide wholly, or contribute largely to, the funds for the schools for the education of these people.

There are, first, the infant schools, which contain 260 children, under the superintendence of nuns, who give them religious instruction and teach them elementary grammar, reading, arithmetic, and geography, and to the girls sewing and other kinds of woman's work. The next schools provided are the elementary schools, which contain 350 boys; they remain until the age of 13 and 14, and receive the ordinary elements of a boy's education. At the age of 14 their technical education and the special duties of the company commence. An apprenticeship in the works of La Ciotat is from beginning to end a course of technical instruction. The superintendents remark with pride that all the foremen and workmen delight in teaching the youth. The company has done away with the system of obligatory apprenticeships for a fixed period. The children not only receive wages from the moment they enter the establishment, but those wages are increased as soon as greater knowledge and skill enable them to do better work.

But their apprenticeship is not merely a school for mechanical dexterity. The company has a school-room, in which all the apprentices are educated gratuitously during one hour of the day, and that hour counts as one of the 10 hours of their day's work. Attendance at this school is compulsory on all the apprentices; but they have in addition an evening school, which those may attend who will. Three evenings a week plan-drawing, designing of machinery, designs of ships, and ornamental drawing are taught gratuitously. Two hundred apprentices and workmen regularly attend this class. The superintendents say that they do not know which to admire most, "the anxiety of workmen and apprentices to obtain admission to this course, the diligence with which they apply themselves to its work, or the order and silence which pervade the school-room." This is really the highest sort of technical education; and there is a strong inducement to take advantage of it in the circumstance that the company selects men for the responsible duty of engineers of steamships from those who have distinguished themselves in this course, and take the highest places in an annual examination at which gold and silver medals are distributed as prizes. The company also provides a library, which is open to their people from eight till ten in the evening and ten till four on Sundays. The formation of bands of music is encouraged. Workmen's houses have been erected, with all modern appliances for pure air, cleanliness, and domestic economy; there are gardens attached to each; each contains a kitchen, a large room with two windows and an alcove, and another chamber with one window; and they are let to the workmen at from 65 to 100 francs a year. With a further view to economy, the company has also organized a market for butcher's meats. It has founded hospitals and savings banks, provided funds for sickness and death, and pays members of the religious orders to attend to the moral and religious education of the people.

Such is the moral and intellectual apparatus provided by this mercantile company for training its workpeople. The next point is, whether all this training really produces the improvement aimed at. We have an official judgment on this subject: "The commissary of police, the justice of peace, the gendarmerie, and the public prosecutor, all state that they are surprised at the small number of misdemeanors and crimes to be met with in the population of La Ciotat." Three facts are adduced as a proof of the high moral tone of the workmen. 1. In 1858, there was an almost total cessation of work in the establishment. Instead of dismissing men, the company decided to employ and pay them only a third of each day, and

the workmen accepted the sacrifice without a murmur. 2. In 1851 the mechanics of Marseilles struck for higher wages, and sent their emissaries to La Ciotat in order to obtain their co-operation; the attempt utterly failed. 3. Those apprentices who have been some time in school differ from those who have just entered, not merely in intelligence and age, but in a higher moral tone and conduct, the result of their education. In a money point of view, the managers say that the company reaps an ample reward in the superior intelligence and steady conduct of their workmen.

MINING EXPERIMENTS.

From "The Army and Navy Gazette."

The approaching completion of the lines of defence at Hilsea, which are intended to cover the only approach to the Island of Portsea from the mainland, has necessitated the demolition of that portion of the lines of defence which cover the towns of Portsmouth and Portsea. In carrying out this work, advantage has been taken of the opportunity for making some mining experiments on a comparatively large scale, which have proved exceedingly interesting to the scientific branches of the service. Under the directions of a committee of Royal Engineer and Artillery officers, accompanied by Mr. Abel, the chymist to the War Department, comparative experiments have been made between the powers of gunpowder and gun-cotton to destroy the walls of the fortifications. The mines in the stone escarp and counterscarp walls have been constructed, charged, and fired by the officers and men of the Royal Engineers stationed at Portsmouth, under the direction of the officers forming the committee and the War Office chymist. The first experiment made was on the right flank of the Portsea line of defence. Four shafts were sunk in rear of the escarp wall of a projecting bastion, two of these being on the front and two on the left face of the bastion. The earth of the rampart, as in all the subsequent experiments, was cut back some fifteen feet from the top of the escarp, so that the weight of the soil on the charge was due solely to the depth at which the mine was fixed behind the escarp. The ordinary service friction battery was used for firing the mines. Three of the four mines behind the two faces of the bastion escarp were loaded with gun-cotton, prepared on a plan recommended by Mr. Abel. The three charges were respectively of 46, 36, and 30 pounds. The fourth charge was composed of 70 pounds of gunpowder. When the explosions took place there was a vast trembling of the bastion at the moment of the explosion, with an upheaval of the escarp and the base of the rampart at its back, great sheets of flame playing strangely over the cotton mines, and four great gaps in the escarp where the mines had been placed, each forming a crater spreading out into the ditch beyond the wall, and filled with stone, changed from square blocks into millions of shapeless splinters. A storming party, six abreast, could have charged through each breach; and what remained standing of the escarp was disintegrated throughout in structure, and ready to fall into the ditch on such slight impulse being given to it as the blow from a round shot of the smallest calibre. The next experiment in such blasting was made on the counterscarp wall of the Lion Ravelin, in about the centre of the same line of works. Here eight holes had been driven with bits at the back of the wall at short distances apart. Four on the right of the wall revetements were each of $3\frac{1}{2}$ in. in diameter and 6 ft. in depth. They were loaded each with 6 lbs. of gunpowder and then tamped in with earth. The other four, on the same face of the counterscarp and adjoining, were each 3 in. in diameter, and were charged with 3.5 lbs. of the pulp disc-formed—or, to speak more correctly, cylinder-formed—gun-cotton. In this latter instance, however, the holes, owing to the obstructions met with in driving the bits, were sunk "out of line," and, as a consequence, the cylinders of cotton could not be packed in them with sufficient closeness to insure results of any value; and, in addition to this fault, the holes were very wet, so that altogether but little was expected from them, and the truth of this anticipation was soon confirmed. The four holes charged with gun-

powder were connected and fired from the friction battery with good effect. The whole of the counterscarp for 16 paces was thrown into the ditch, and some of the large stones projected as far as the water channel in the centre. The stones of the counterscarp on either side of the gap were bulged outwards, and entirely disintegrated from each other for about three yards.

The general object of these experiments is not only to test the comparative merits of gun-cotton and gunpowder as the means of demolishing fortifications, but also to find out the best and most portable preparation of gun-cotton which can be used on actual service. Mr. Abel has devoted a great deal of time to this subject, and is now testing the various preparations he has prepared of this explosive. The ultimate results can only be known after the official report has been sent in to headquarters, and as yet the experiments themselves have not been brought to an end. But, so far as the various minings have been tried, it seems that more than one of this gentleman's preparations are highly approved of by the officers who were present. One of these preparations is in compressed discs, the cotton being reduced to a pulp as in the cylinder form, and with this two (preliminary) trials were made, which were very interesting, and may bear some discussion on the causes of the results obtained with them. The cotton is compressed in discs of about the diameter of a small tea saucer, and about $\frac{3}{4}$ in. in thickness, weighing each about 7 or 8 ozs. One of these discs was placed on one of the massive coping-stones of an escarp masonry wall and fired by wire connection with the friction battery. The disc exploded with a sharp ringing report equal to that of a shotted 40-pounder Armstrong gun, and the coping-stone, on examination, was found to be shattered, as it lay wedged in its bed between the other stones, into a hundred pieces. The next experiment with these discs was made with 16 of them strung together (in two lengths of 8 in each), and hung against the face of a counterscarp masonry wall. If the one disc had done a certain amount of damage to the coping-stone of a counterscarp, what was to be expected from 16 such discs exploded together on the face of the counterscarp? The difference in the two cases was this. The single disc lay with its flat surface resting upon a flat stone. The 16 discs hung against the face of the stones, and not upon them, and the edges of the discs—not the flat surfaces of the latter—only touched the wall. When the hung discs were fired they emitted a blinding sheet of light, and sent out a hard ringing detonation, equal to that of the heaviest ordnance, but clearer and more metallic than the voice of any gun ever yet fired. The result was somewhat astonishing. The 16 discs had done less execution than the one. Where they had hung against the wall the stone had "scaled" off to the depth of two inches, and this, with the exception of a little shaking at the joints, was all. The intention in both instances was to deliver a blow, steam-hammer fashion, on a stone-fronted work that should make a sufficient hole in the face of the work for a man to rush up to, under cover of rifle fire, and deposit a second charge, the end being, of course, that a sufficient charge should be at length exploded in the hole thus made, to bring down the wall and make a breach to the attacking party.

NEW MODE OF SETTING BOILERS.—Several boilers in Sheffield have been set upon a new plan. By a simple arrangement of fire-clay plates, says the "Sheffield Independent," so managed as not to contract the capacity of the flue, at any single point, the gases, after being thoroughly intermixed, are at four successive stages in their progress through the flue, thrown, in thin streams, against the surface of the boiler. No part of the gases can escape this repeated forcible contact with the boiler, and in the process the heat they contain is so thoroughly extracted and absorbed that the result obtained, as proved by careful tests, is the evaporation of nearly 12 lbs. of water for every single pound of fuel, common boiler slack being used. This gives a large saving of fuel as compared with the best modes of setting previously in use. The patentees, we understand, guarantee a saving of 25 per cent. The apparatus has the additional advantage of being an effective smoke-consumer. The plan is applicable to any class of boiler; can be applied without unsealing boilers already fixed; and the plates being of fire-clay, the cost is so moderate as to be very soon repayed by the saving of fuel.—*Builder.*

FURNACE BOILERS.

From "The Engineer."

The jury empanelled to hold an inquest on the eight men killed by the explosion at the Britannia Ironworks, Bradley, have returned a verdict over which all sensible men will rejoice. They found that the deceased persons lost their lives by the explosion of an old and much worn steam boiler, and, in addendum, they expressed a hope that what had been disclosed at the inquest might be a warning to the owners of boilers, and to persons whose special duty it is to look after and examine such machinery. The jury stated that if it had appeared to them in evidence that notice of the dangerous state of the boiler had been given to any person whose duty it was to attend to it—whether master, owner, or servant—and that such notice had been neglected, and that death had ensued in consequence, they would have returned a criminal verdict against the persons who had neglected so important a duty. This verdict strengthens the hope that the day is not distant when juies called in to determine how men come to their deaths in our ironworks and our factories, will return verdicts in accordance with the evidence, and with common sense.

In another place we have spoken fully and freely on the evils attending on the existing system of repairing boilers, and it is not our purpose here to dwell at length on that subject. The failure of the Bradley boiler, however, points a moral which it is as well we should draw; and gives force to the statement that boiler engineering, as exemplified by ironworks practice, is of very nearly the worst possible kind. Not only do explosions occur with alarming frequency in our iron districts, but they are attended by a loss of life without parallel. Such effects can only follow on well-known causes. The facts tell us as plainly as possible that furnace boilers are overworked, badly made, inefficiently attended to, and improperly located. This testimony of facts has never, so far as we know, been disputed; yet we are at a loss to find any evidence of a general desire on the part of those engineers who design ironworks to adopt a better practice. In a few isolated instances, indeed, the case is different; but such displays of forethought and skill, only make the general practice of furnace boiler engineering appear in a still worse light. A very few years since, it was considered by many eminent iron manufacturers, that no saving in fuel was to be expected from the use of the waste heat of puddling and reheating furnaces in raising steam. This was a fallacy, and a reaction set in, which resulted in the belief that any amount of steam could be had from the waste heat of furnaces, and that it was quite unnecessary to be particular as to the form of boiler used to raise steam, or as to the qualities of the engines employed to utilize it. This is, if possible, a worse mistake than the first; it is certainly a fatal mistake in some respects, whereas the first was only an economical mistake. That steam enough can be raised from the waste heat in an ironworks, to do all the rolling and forging necessary, without the aid of hand-fired boilers, is certain; but it is not less certain that to attain this desirable end the boilers must be properly designed, and the engines so constructed that they will be at least fairly economical. The waste heat of any average ironworks is not more than necessary, and if it be improperly used, either hand-fired boilers or an extravagant consumption of fuel will be found absolutely necessary to keep up the proper supply of steam. It is impossible in an article like the present, to discuss all the questions that will suggest themselves to the engineer-manager of an ironworks; but we shall call attention to one or two points which greatly influence the yield, estimated in terms of power, to be had from waste heat.

The first thing to be done is to see that the machinery driven runs as lightly as possible. In how many mills do we find the smallest attention paid to this point? We see rolls out of line, standards loose and askew in their bed plates, roll necks turned oval or eccentrically to the roll bodies, coupling boxes and spindles put together "anyhow;" gearing—well, the less we say about rolling mill gearing, especially in old mills, the better. A maximum of metal is intended to compensate for the absence of good design, fair proportions, and accurate workmanship. We venture to assert that 50 per

cent. of the power required in most rolling mills is expended in driving the machinery, and we challenge the old school of ironworkers' engineers to dispute the statement. Here, then, is one source of waste; enormous quantities of steam are required to overcome a resistance which should not exist, and the boilers are expected to compensate for all deficiencies. It is astonishing what a difference there is between a well set up mill and one out of line and out of order in the matter of resistance.

If we turn to the engines we find them, as a rule, still worse than the mills; it is impossible to conceive how bad a steam engine can be without going into our iron making districts. Anything that will turn a wheel round will do. The piston and valves may be leaky, the bearings all pounding and banging, the shafts out of truth, the guide-blocks thumping up and down in the slide bars, or the parallel motion all wrong; the foundations loose, the cylinders and steampipes unlagged; the joints all blowing; still the excuse is, "She will drive the mill if there is only steam enough behind her, and it costs nothing to get steam because of the waste heat." In practice we find, as a result, that much more steam is got out of the boilers than there is any need for, and that fuel is wasted by working furnaces harder than they need be worked; but even this will not suffice. A case came under our notice the other day in which a firm was compelled to keep on making puddled bars for sale for which they had no need, and by which they lost over £800 a year, in order to keep steam to drive a mill working on finished iron. No fewer than 16 furnaces, burning 320 tons of coal per week, were employed to get at most 300-horse power. This is, perhaps, an exceptional case, but it is not very exceptional. We know, for example, that another firm in the north pay £3,000 a year for fuel in hand-fired boilers alone, required to supply steam in addition to the furnace boilers. Now, our experience goes to prove that any one furnace will, on the average, where plenty of furnaces are employed, supply steam enough to roll all the iron it can heat into bars or sheets. The same will hold good of puddling furnaces as regards the conversion of the puddled balls into puddled bars, and it follows, therefore, that the waste heat in any ironworks of moderate dimensions is sufficient, if properly used, to find power for that works, so that hand-firing boilers are totally unnecessary.

In order to secure this end, however, the mills must run with a minimum of frictional resistance. The steam pipes must be clothed, and the engines must work to a considerable extent expansively. These things in themselves will accomplish a great deal, but the very essence of success lies in the construction and arrangement of the boilers and furnaces. The first should be so arranged, and of such dimensions, that they may take up all the heat except that required to secure a good draught, which is to be promoted by the use of high chimneys; and the furnaces should be so disposed that the smallest possible distance may intervene between the furnace throat and the boiler. It is commonly assumed that the heat will be too intense, and will injure the boiler if the furnace neck is short; and this is perfectly true, if, firstly, the flame is allowed to impinge directly on the boiler plate; or if, secondly, it is shut up closely in the small cylindrical flue of a Cornish boiler. We have seen scores of such boilers, the flues of which were traversed by a perfect hurricane of flame, yet not making very much steam after all, because much of the tube had to be lined with brick to protect the plates. By allowing the flame to spend itself in a large space, the brick walls of which become red or white hot, and radiate heat to the boiler, all risk of injury may be avoided and plenty of steam made; while it is certain that a very moderate increase in the distance intervening between a furnace throat and a boiler will very greatly reduce the steam-producing powers of the latter, especially with some kinds of coal.

The prominent defects of the ordinary vertical furnace boiler are, that it is enormously too large in diameter, and that all the heating surfaces, or nearly all, are vertical, and, therefore, little more than half as efficient as horizontal surface. In addition, these vertical boilers always stand in the middle of a crowd of workmen who cannot possibly escape if the boiler bursts. The great defect of the double and single-flued Cornish boiler is, that the flame is too concentrated, and that there is nothing like heating surface enough provided unless the boiler is made

of extravagant length. The small quantity of water contained is also an evil. As to what is really the best form of boiler, we shall at present say nothing. That is a branch of our subject to which we shall return. One point is worth notice. In some works all the waste gases from the furnaces are led into a single culvert, and thence taken to a bed of boilers to be employed in raising steam. The gases so taken from a good heating furnace are worthless. All the air required to secure complete combustion has already been admitted through the bars, and nothing will escape from the furnace that will not be consumed within a couple of yards of the furnace neck. It is really the waste *heat*, not the waste gases, of such furnaces that must be utilized in raising steam. The case is different with puddling furnaces, because in certain stages of the puddling process air is not freely admitted, and the products of combustion can be led to a distance and consumed as though they came from a blast furnace.

But prominent above all other considerations is that of securing perfect safety to the hands employed. Furnace boilers are above and beyond all other boilers dangerous. They are exposed to a temperature higher than other boilers, but excessively and rapidly variable. The water with which they are fed is often bad; they are exposed, in a word, to abnormal and potent deteriorating agencies. In our ironworks, beyond all other places, is inspection required; and, glancing over the fearful record of boiler explosions in ironworks which have occurred within the last few years, we feel almost disposed to endorse the wishes of the Bradley jury, and to hope that Parliament would undertake the inspection of steam boilers generally, by the appointment of proper officers. We cannot go quite so far as this, however; but we do trust that such a measure may be passed during the next session as will insure the proper examination of all steam boilers, though not necessarily by Government inspectors. Such an act has become absolutely necessary. If it is not asked for and obtained by users of steam power, others will insist on the passage of a very different law, infinitely more troublesome and arbitrary in its character.

A SHORT HISTORICAL SKETCH OF METALLIC ZINC.

From "The Mining Journal."

If we may depend on the traditions and records of the Chinese, we learn that they were acquainted with metallic zinc at a very early period, and we must ascribe the first discovery of the metal, like that of so many other concomitants of our modern European civilization, to the inhabitants of the East. The fact is, that the metal was imported from India by the Portuguese, in the seventeenth century, under the name of spianter, or spialter, before its nature was recognized in Europe. Whether the ancient civilized nations of the West were acquainted with metallic zinc cannot be ascertained, but there is a great probability that they were. The high degree of development of some of the ancient nations on the shores of the Mediterranean, with regard to metallurgical operations, their very extensive manufacture and use of brass, make it most likely that they knew also metallic zinc, and some way of extracting it from its ores. It is true that the writings of the old Greek and Roman authors do not refer to it; it appears, on the contrary, that they regard brass and yellow metal as only a colored copper, and the Greek word "chalkos," as well as the Latin word "aer," meant both copper and brass, though some authors, as Strabo and others, used sometimes the word "aurichalcum" for the latter. This, however, only related to the color, and meant nothing but a gold-like copper. If we consider the difficulty of communication, the continual and violent political revolutions in the ancient world, the absence of all the present facilities for spreading and preserving any knowledge—further, the fact that our historical sources consist chiefly of the fragmentary writings of a few philosophical scholars, we may easily conceive the possibility that some ancient knowledge may have been entirely lost to us. Our oldest historical documents are the writings of Aristoteles (fourth century B. C.) and Dioskorides (third century

B. C.); they only refer to the manufacture of brass, by admixing an earthy substance ("kadmea") with the copper. The latter author also mentions the application of zinciferous deposits from the brass kilns for the same purpose, and distinguishes from it the white oxide or flowers of zinc, under the special name of "pompholix." In his description of the latter substance he compared its appearance to that of wool, which gave rise to the newer alchymical name of "lana philosophica," much used by the authors of the middle ages.

As, in general, the principles of the Alexandrian scholars, and especially those of Dioskorides, were forming the foundation of natural science for a long period, so it was also the case with regard to their views on brass, and the other zinciferous substances. The following Roman authors —Pliny, sen. (first century A. D.), Strabo (first century A. D.), and Festus (fourth century A. D.), who left us some treatises on natural history — adhered to those principles, and throughout the whole middle ages, down to the latest time, we find them prevailing; the only thing worthy of remark for our purpose during that period is the origin of some words relating to zinc.

From the fifth century A. D., we find the name "jutia" employed instead of "kadmea" or "cadmia," as well for calamine as for the zinciferous furnace deposits. Zosimus in the fifth, Geber in the eighth, and Avicenna in the eleventh century, make use of it in their treatises on brass smelting. Some Arabian authors, also, employed the word "clymia," or "calimia," synonymously with "jutia," from which words subsequently calamine or "lapis calaminaris" was derived. The latter word appears first in the writings of Albertus Magnus, in the thirteenth century. He made a distinction between "calaminaris" and "jutia," applying the former word to the natural mineral, and the latter to the zinciferous furnace deposits, and considers them both equally applicable to brass making. The word "zinc" or "zinken" is of later origin. We find it employed, first, in the fifteenth century by Basilius Valentinus, without, however, any clear definition accompanying it, which even leaves it uncertain whether he meant a metal by it or some other zinciferous substance. The first who described metallic zinc by that name, and undoubtedly in accordance with some of its real properties, was Paracelsius (sixteenth century), although it would appear that his notion did not generally prevail, for down to the end of the seventeenth century a general confusion existed about the use of the word. Some authors employed it for the zinciferous furnace deposits, some for bismuth, cobalt, and other metals. It was only at the commencement of the eighteenth century that the ideas on the nature of brass and zinc became clearer. Kunkel announced in the year 1700, and Stahl conclusively in 1718, that calamine required to be reduced to zinc before it would combine with copper during the brass smelting process. The notion prevailed, however, for some years afterwards that a reduction of calamine into metal was only practicable when copper was present, until Schwab in 1742, and Markgraf in 1746, published some methods of zinc distillation by means of fire-standing retorts.

From this time we meet also with credible records of practical enterprises for carrying out the distillation of zinc on a large scale. For many centuries three districts in Europe were chiefly noted for producing zinc ores—some parts of the South of England, the neighborhood of Aix-la-Chapelle, near the Rhine, and the environs of Beuthen, in Upper Silesia. It is certain that the calamine mines of Altenberg, near Aix-la-Chapelle, have been worked from about the year 1430. In 1565 the first concession was granted for starting a calamine mine, near Beuthen in Silesia, where many mines were soon after opened, of which the Scharley-grube was, and is still, the richest. At all these places the ore formed an important article of trade, and was sent (especially from Aix and Beuthen) to the various distant brass works. It is obvious that from these places the first efforts proceeded for extracting metallic zinc on a large scale, and in England, Dr. Isaac Lawson seems to have been the first who succeeded in introducing a practical method for that purpose; certain it is that in the year 1758, a patent was granted in the name of Champion for a method of extracting zinc from blende, called at that time "black jack," "mock jack," or "bragill." The first works were erected in the neighborhood of Bristol, and were described by Watson, who visited them in

1766. According to his reports, their method was very similar to that in use in England to so recent a period as 20 years ago; it was a "distillatio per descensum," and forms the basis of the old English system for reducing zinc. In this process the distillation took place in closed crucibles; the volatilized zinc was made to pass through an orifice at the bottom of the crucibles into a vertical iron tube, where the vapors of the metal were condensed, and dropped into a vessel containing water standing beneath it. The furnaces used were either rectangular or round, with a fire-place in the middle, surrounded by the crucibles. This method was the only successful one employed throughout Europe for even about 50 years, and it attained considerable development, so that it competed for even 20 or 30 years longer with the newer methods, which are generally adopted under the name of the Belgian and Silesian systems, and which are more open to modifications and improvements. Both these systems originated about the beginning of the present century, when almost contemporaneously (in the years 1808 and 1809) patents were taken out by the Abbot Donny at Liege, and J. Chevalier Ruberg at Wessola, in Silesia, for new methods of reducing zinc.

The principal difference between the three methods mentioned lies in the form of the clay vessels or retorts introduced for the reduction and distillation of the metal. In the English process that vessel consisted of a large crucible, in the Belgian it represents a cylinder, and in the Silesian process a somewhat oblong, flat-sided tube, termed muffle. It is hardly necessary to say that this difference in the shape of the retorts arose originally from the way which the inventors found to succeed best in their first trials to extract the metal. Ruberg, for instance, performed his first experiments by means of a common assaying muffle, as used for cupellation. These muffles are generally of a semicircular front, and so we find them also employed for the zinc smelting process in Silesia to about the year 1835, only of larger size. The peculiar shape of the retorts influenced the arrangement of the furnaces of the different systems. Of the Belgian tubular retorts several horizontal rows could be placed in one furnace, forming an arched chamber with a fire-place beneath, whilst the flat-bottomed muffles only allowed of the arrangement of a single horizontal row along both sides of a fire-place, covered over by a flat arched vault. By such a disposition it was practicable, both in the Belgian method as well as in the Silesian method, to fix the condensing apparatus entirely outside the furnace, convenient to the workman, and facilitating as much as possible the operations of charging and discharging the retorts. This is one of the great advantages which the two newer systems exhibit in comparison with the old English one. Another is in the practicability of enlarging the furnaces, the original size of which was undoubtedly small. Even the first improvements were not as much directed towards the enlargement of the furnaces as towards that of the retorts. In the first place, the necessary temperature for the reduction of the zinc ores, and especially the great advantage of a swift process, were underestimated. Most of the Silesian zinc works, to the year 1835, employed muffles of 18 in. width inside, which of course only required to be charged once every two or three days, without even then allowing of a complete exhaustion of their charges. Similar anomalies we meet with also in the Belgian system. The size of the retorts forms, no doubt, one of the most important elements in the zinc smelting process, and the development of our two present methods is chiefly due to the recognition of this fact.

It has been mentioned already that in the second half of the last century the first zinc works were commenced in England; so also the discovery of the two methods in Belgium and Silesia was soon followed by the erection of zinc works in those countries. The first one in Belgium was that of St. Leonard, at Liege, and in Silesia, the Lydogniahuette, at Kœnigshuette, both starting about the years 1809 and 1810.

However, the practical application of metallic zinc was still at that time a very limited one. Zinc was regarded as a brittle metal, not suitable to be worked by itself, and though Hobson and Sylvester, at Sheffield, proved by some experiments, in the year 1805, its ductility and fitness for being rolled into sheets, the only application of it was to the manufacture of brass and yellow metal; but even for this purpose the use of calamine was kept up for

some time. No wonder that the demand for spelter, and, consequently, the activity of the smelting works, were very limited. At intervals, under the influence of speculation, the price of the metal advanced sometimes to a considerable extent, but only to decline afterwards. No metal has undergone in modern days such extremes in price as spelter ; frequently we find it varying on the Continent from £10 to £75 per ton within the last fifty years, and it is obvious that such a state of things could not be favorable to the development of the spelter trade in general.

Step by step, however, this unsteadiness ceased with the rapidly spreading recognition of its almost unparalleled advantages for many technical purposes. Great progress was made in this direction by the successful application of the metal to artistic and monumental castings, applied first at the Royal Iron Foundry at Berlin, in the year 1833. Even in the earliest times bronze was proved to be the metallic substance most suitable for such castings, and it will, no doubt, continue so for the classic monumental art. The costliness of bronze, however, limits considerably the common use of it in the ornamental line, and the want of a more generally applicable substitute led long ago to many experiments with cheaper metal, as, for instance, cast-iron, and even lead. The difficulties connected with the casting of large iron statues, and with the chiselling of them afterwards, are great points against the use of this metal, whilst its exceeding softness, ponderosity, and consequent instability, render the latter almost unfit for the purpose. Zinc, on the other hand, offers, by its natural properties, and its comparatively low price, every qualification for it. The only difficulty in its employment lay in the method of casting. Experience showed that full round castings of zinc would not succeed by means of the traditional closed loam moulds, and it is the merit of the above-mentioned foundry to have introduced a new method which offers many considerable advantages over the old one. The principle of this new method lies in the casting of zinc in different parts in open sand-moulds, and in joining such parts afterwards by soldering. This process has now been brought to extraordinary perfection, and, united with some modes of pressing sheet-zinc into ornamental articles, and of producing small hollow castings by means of cast-iron moulds, forms the principal industry of large establishments.

Great progress in the application of zinc was also made by substituting it for tin as a protecting coat for iron articles, chiefly for iron sheets for roofing, etc. The first patent for coating iron with zinc was granted to Mr. H. W. Crawfurd in 1837. His process, described in the "Repertory of Patent Inventions," is almost similar to that still in use at our present galvanizing works. It consisted briefly in cleaning the iron objects by immersion in a bath of water, acidulated with sulphuric acid, scouring and washing them afterwards, and dipping them into melted zinc, covered with a layer of sal-ammoniac. They were then slowly removed, to allow the superfluous zinc to drain off, and thrown, whilst hot, into cold water. Iron treated in this way shows a great resistance to the destructive influence of the atmosphere, and the application of this process, therefore, came soon into general use. We may estimate the quantity of spelter now consumed in Europe for zincking or galvanizing purposes to be above 10,000 tons per annum. The above-named properties of zinc rendered it one of the most useful metals; and, moreover, if we add to this its high importance for the electric telegraph, and its enormous consumption in the form of sheets, as well as oxide, we can readily account for the present great development of the spelter trade. It is impossible to name all the purposes for which zinc sheets have been introduced, with almost unparalled success during the last 30 years, and the number is still evidently increasing. It will, probably, be the subject of an extra paper to go more extensively into this matter, in connection with the rolling process, and the manufacture of zinc oxide.

With the beginning of the fourth decenary of our present century we find metallic zinc to have gained ground so far in manufacture and art, that it appeared quite indispensable to them. In the chief calamine districts of Europe large companies were formed for extracting and working the metal, and, though some great fluctuations in the zinc market were experienced, as, for instance, in the years 1848 and 1849, when the price of zinc in

Breslau (capital of Silesia) declined to an average of only £11 5s. per ton, yet a rapidly increased demand, and a proportionate production, always followed. The average price of spelter has been for the last 20 years about £20 per ton; the maximum price during this period was that of the year 1857, when it averaged £27 6s. per ton, and the minimum that of 1861, with an average of £15 7s. 3d. per ton at Breslau.

The yearly production of spelter in Europe amounts now to 100,000 tons at least, of which quantity about 50,000 are made in North Germany, 35,000 tons in Belgium, and 15,000 tons in England. The largest establishments for smelting and manufacturing the metal are those of the Vieille Montagne Company, in Belgium; the Schlesische Actiengesellschaft, in Silesia; and the works of Messrs. Vivian and Sons, in England. The metal has attained an importance through the whole civilized world, which places it amongst the most valuable treasures of national wealth in several countries, and ranges it by its applicability and cheapness next to iron amongst our most useful metals. Large quantities are annually exported to the remotest places of the globe, and it is curious, and no less satisfactory, to note the alteration in the direction of the spelter trade. Two hundred years ago we find the metal was exported from India to Europe; now large shipments of it (by far larger quantities than we ever received) are being made from Europe to Asia.

DESCRIPTION OF THE HYDRAULIC BUFFER.

By COLONEL H. CLERK, R.A., F.R.S.

From "The Engineer."

In consequence of a suggestion made to me in October, 1867, by C. W. Siemans, Esq., C.E., F.R.S., to try the effect of water to check the recoil of heavy guns, I submitted to the Secretary of State for War a compressor or buffer on the above principle. It has been tried with guns varying in weight from only 150 lbs. up to 25 tons, and in all cases the results have been most satisfactory. The amount of recoil can be regulated to a great nicety, and the motion is smooth and regular.

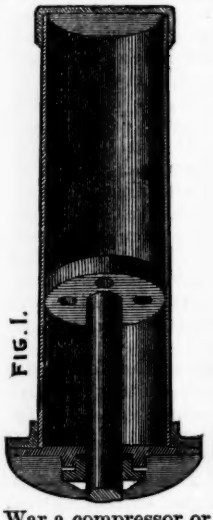


FIG. 1.

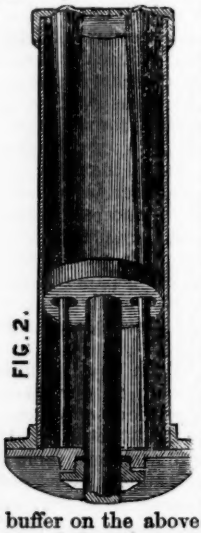


FIG. 2.

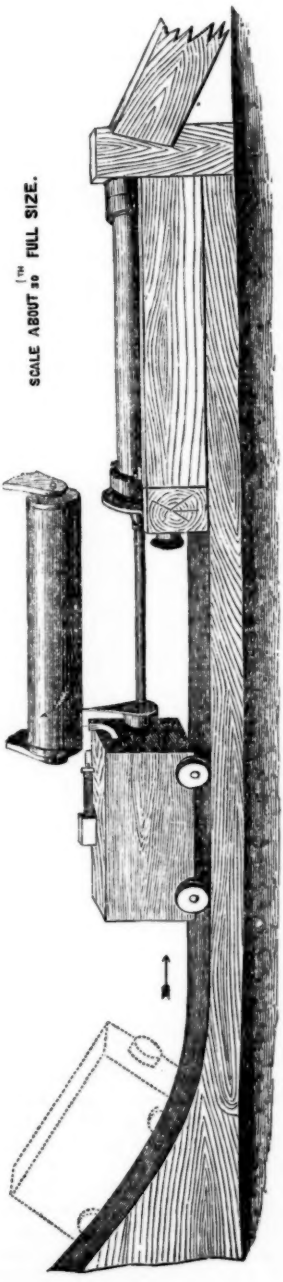
It consists of a wrought-iron cylinder closed at one end, the other end fitted with a cap and stuffing-box, through which a piston-rod passes. The length of the cylinder and piston-rod are regulated by the amount of recoil required, or the space within which it is necessary to bring the moving body to rest. The piston fits well into the cylinder, and is perforated with four small holes. The ratio between the diameter of these holes and that of the cylinder is determined by the amount of work required to be performed on the water with which the cylinder is filled, enough air space being left to allow of the displacement of water by the length of the piston-rod due to the recoil. This air space also acts as an elastic buffer, and takes off the violence of the first impact of the piston on the water. The cylinder is firmly attached to the platform on which the carriage recoils, and the end of the piston-rod to the carriage itself; so that on the discharge of the gun the carriage drives the piston through the water with an initial velocity V, whilst the water has to pass through the holes with an initial velocity R V, R being the ratio between the

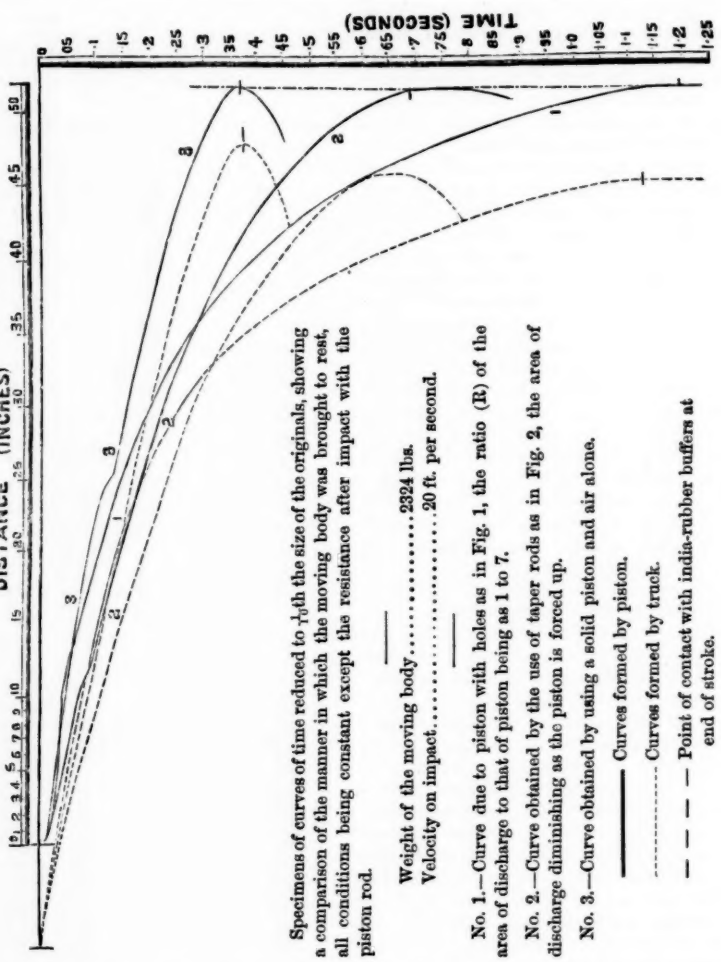
area of the cylinder and of the holes. This buffer has not only been used on shore with guns up to 25 tons weight, but also at sea, with light guns of only 1½ cwt. and 8 cwt. in boats, and lately with 9 in. guns of 12 tons on board H.M.S. Prince Albert, in all cases with equal success.

In place of water it has been recommended to use oil, as there is less chance of corrosion taking place if the cylinder is kept full for any lengthened period, and no danger of the fluid freezing in ordinary frosts. The oil used for this purpose is Field's Rangoon oil, which does not become thick except in very cold weather, when Field's non-freezing oil may be used. A small quantity of caustic soda in the water has been found to keep the cylinder perfectly clean and free from rust for many months. The satisfactory manner in which this buffer has worked in checking the recoil of a gun of 25 tons weight leads me to anticipate that it could be most usefully applied towards preventing, or very sensibly diminishing, the destructive effects of a railway collision, for, as by means of this hydraulic buffer a force of impact varying from 1,200 foot-pounds up to 54,000 foot-pounds has been easily overcome in distances from 16 ins. to 60 ins., and on inclinations varying from + 10 degs. to — 4 degs., I see no reason why the principle should not be extended to overcome a force of, say, 1,500,000 foot-pounds in 60 ins.

In checking the recoil of a gun the velocity to be dealt with seldom exceeds 10 ft. or 12 ft. per second, but in the case of a railway collision it is very different; there we have to deal with very high velocities. It is, therefore, necessary to ascertain how the hydraulic buffer will act under these circumstances. For this purpose I have been carrying on a series of experiments at velocities up to 44 ft. per second, or 30 miles an hour, and now forward a short account of them for the information of the members of the British Association.

Two sets of experiments have been made, one with a cylinder 4 ins. in diameter, the other with one 8 ins. diameter. With the former the velocities tried were 10 ft., 15 ft., 20 ft., and 25 ft. per second, with weights of 2,324 lbs., 1,162 lbs., and 581 lbs., and with ratios between the diameter of cylinder and holes in the piston of 15, 21, and 27. With the latter the





Specimens of curves of time reduced to $\frac{1}{10}$th the size of the originals, showing a comparison of the manner in which the moving body was brought to rest, all conditions being constant except the resistance after impact with the piston rod.

Weight of the moving body.....2324 lbs.
Velocity on impact.....20 ft. per second.

No. 1.—Curve due to piston with holes as in Fig. 1, the ratio (R) of the area of discharge to that of piston being as 1 to 7.

No. 2.—Curve obtained by the use of taper rods as in Fig. 2, the area of discharge diminishing as the piston is forced up.

No. 3.—Curve obtained by using a solid piston and air alone.

——— Curves formed by piston.
- - - - - - Curves formed by truck.
— — — Point of contact with india-rubber buffers at end of stroke.

velocities were 10 ft., 15 ft., 20 ft., 25 ft., 30 ft., 35 ft., 40 ft., and 44 ft. per second. The weights were 1,162 lbs., 2,324 lbs., and 4,648 lbs.; the ratios 15, 12, 9, 7, and 6. The velocities were obtained by drawing a truck (loaded to the proper weight) up an incline plane of 47 degs. to the proper height, and suddenly releasing it, (a small deduction has to be made for friction). The truck ran down the slope, and striking the end of the piston-rod drove it in, till the resistance of the water overcame all the force of the impact. The cylinder, with piston-rod drawn out, was fixed at the bottom of the incline plane, about two trucks' length from the end of the slope, and was securely bedded in a block of wood propped up behind to prevent its moving. Above the cylinder was fixed a light barrel, 6 ft. in length, made to rotate at the rate of one revolution per second, on which was fixed a sheet of drawing paper; to the end of the piston-rod was fixed a pencil, kept in contact with the rotating barrel by means of a light spiral spring, so that at each collision the piston-rod transferred to the paper a curve showing the time occupied in pass-

ing over every portion of the space through which it was driven. From these curves a series of tables have been formed showing the velocity of the piston-rod for every 2 ins. of the stroke. The diameter of the rotating barrel was 12 ins., so that one second of time was represented by a space of 37.7 ins. Another pencil was attached to the truck in a similar way to the one on the piston-rod; thus two curves were obtained—one of the motion of the piston through the water, the other of the truck when in contact with the piston-rod. A disc of Clarkson's material (a combination of cork and leather) was fixed to the end of the piston-rod, and another to the front of the truck where it came in contact with the piston-rod, in order to deaden the force of the blow. Two discs of india-rubber were fixed to the wood block in which the cylinder was bedded, against which the truck struck in those cases where the force was sufficient to drive the piston right home. The amount that those india-rubber discs were compressed was self-registered, and the value of such compression in foot-pounds having been previously ascertained, we are enabled to estimate the remaining force with which the truck struck the cylinder block at low velocities. By varying the amount of water in the cylinder we could arrange that the truck could just touch two percussion caps fixed on a plate in front of the india-rubber rings without exploding them, the force required to explode a cap being about one foot-pound.

In order to ascertain the effect of the collision on the truck, or rather, what would be the shock a passenger would receive under such circumstances, a weight of about 6 lbs. was attached by a piece of thread (to keep it in its place on the incline) to the end of the truck farthest from the piston-rod. On collision taking place the thread was broken, and the weight driven forward for a space of 12 ins., when it struck against a spiral steel spring, and compressed it according to the force with which it was struck. By means of a pencil attached to the spring, the amount of compression was self-registered, and the value of this compression having, as in the case of the india-rubber rings, being previously ascertained, the force in foot-pounds with which the weight was driven against the spring was obtained. The same relative quantities of water and air were used in all the experiments: In a 4-in. cylinder, water, 380.6 cubic ins.; air, 97.8 cubic ins.; total capacity of cylinder, 478.4 cubic ins.; diameter of piston-rod, 1.5 in. In an 8-in. cylinder, water, 2,794 cubic ins.; air, 424 ins.; total capacity of cylinder, 3,218 cubic ins.; diameter of piston-rod, 2.375 ins. Ratio of thickness of piston to diameter of holes $2\frac{1}{2}$ to 1.

Different descriptions of fluids, such as oil, glycerine, and methylated spirit, were tried as well as water. Some of the curves thus obtained were exhibited in diagrams at the meeting.

With a perforated piston the resistance of the water is not uniform, being greatest at the commencement, or rather at that point where the air has received its maximum compression. It was therefore considered desirable to try the effect of uniform resistance, and Mr. Butter (Constructor R. C. D.) suggested a very simple mode of doing this. It consisted in fixing along the length of the cylinder four tapering rods, which passed through the holes in the piston; these holes were considerably enlarged, and the smallest ends of the rods being towards the front, there was a large area for the water to pass through in the first instance, gradually diminishing in proportion to the increasing velocity of the piston, thus keeping up an uniform velocity of flow through the holes. Some of the curves obtained with this arrangement, together with section of the buffer, are shown in the diagram above. In order to get the effect of an air-buffer, for the sake of comparison, a solid piston, fitting well in the cylinder, was also tried.

THE following is a German recipe for coating wood with a substance as hard as stone: Forty parts of chalk, fifty of resin, and four of linseed oil, melted together; to this should be added one part of oxide of copper, and afterwards one part of sulphuric acid. This last ingredient must be added carefully. The mixture, while hot, is applied with a brush.

THE temporary Blackfriars Bridge is rapidly disappearing; the footways are already in great part removed.

ANGLO-FRENCH COMMUNICATION.

By ZERAH COLBURN.

From "Engineering."

From the period of the Roman invasion down to the present day, the English Channel has never been crossed otherwise than upon its own surface—unless the late Mr. Green's aërial voyage be an exception. Neither Julius Cæsar, however, nor William of Normandy lived in a railway age, and but for the miseries of seasickness, they doubtless preferred the sail to the best roads of their respective times. But since railways have become the recognized means of communication on land, the question has been pressed, and of late very urgently pressed, whether they may not be also made available for communication—not exactly upon the water, although there is a floating railway across the Upper Rhine—but over or beneath the water, and especially over or under the comparatively narrow and shallow strait which separates our island from the Continent. There are *soi-disant* patriots, it is true, who would on no account witness the loss of our absolutely insular position, patriots to whom England is a castle, and the stormy Channel its moat, and who would not have so much as a drawbridge thrown across that moat, or a hidden way mined beneath it. Such considerations are, however, apart from the present purpose, which is, not to inquire into the international policy or financial expediency of solving this great intercostal problem, whether by a bridge, ferry, or a tunnel, but to examine, very briefly, the engineering and constructive aspects of these proposed works. It is probable that the greater the apparent impracticability of either or all of these schemes, the greater the general interest they attract, and perhaps the same interest may be said to exist also among the members of the engineering profession.

The question of bridging the Channel has been mooted, and at least one scheme has attained some degree of public prominence. The designer's first proposal was to jump the Channel at a single leap; but whether out of his regard, as has been asserted, for the wishes of the Emperor, or from a willingness to conform to certain immutable laws of nature which render such a plan impossible, he subsequently modified his design so as to include ten spans, and it has been since heard that he is willing to extend their number and reduce their width to twenty, of one mile each. Whether even such a superstructure, to say nothing of the piers in a maximum depth of 200 ft. of water, and rising more than 200 ft. above its surface, would or would not be practicable, is a question which may be safely left to those really competent to deal with it, and of these the designer himself can hardly be considered to be one.

Of the entire practicability and great advantage of a Channel ferry there can be no doubt whatever, whether it be established between Dover and Calais, or between Dover and Audrecelles. It is quite practicable to ship and unship passenger and goods trains bodily, and thus to run them through, both ways, between London and Paris. Boats suited for this purpose, and harbors capable of receiving them, could be constructed within a few years at a cost much less than that of any tunnel, whether laid on the bed of the Channel, or carried through the chalk at any depth below it. Such boats would be in as striking contrast to the existing Channel service as that afforded by our finest hotels on the one hand, and the most uncomfortable lodging-houses on the other; or, if another illustration be needed, the most luxurious express saloon carriage and the most cheerless third-class conveyance to be found on any railway in the kingdom. But any boat service whatever, however excellent it may be, has its necessary drawbacks. No ferry boat, even if nearly as large as the Great Eastern itself, could wholly prevent the possibility of sea-sickness, that unspeakable horror of so large a proportion of all landsmen, of whatever nationality. The time occupied in shipping and unshipping trains, however expeditiously the work was performed, would be considerable, and however, high the speed of the boat as a boat, it could not exceed one-half that easily attainable by a railway train. As to the relative safety of a boat service and a train service, it is not now necessary to inquire, although something, if

not, indeed, much, might be urged with reference to collisions in fogs or storms. But the chief objection to boats would be their high cost of working and maintenance. As it would not answer the convenience of the public to detain a boat until two, three, or more trains had arrived at either port, a boat would be required for every train, and its working charges might, therefore, be fairly compared with those of a single train. The consumption of coal alone, with boats of the proposed size and speed, would be from fifteen to twenty times as much as that for the train if run across by itself. The repairs and depreciation of the boats would be very much greater, per pound of their value, than that of the train, and the boats themselves could hardly cost less than £100,000 each, while the train carried, including the cost of engine and tender not carried, would not represent a cost much above £6,000 or £8,000. The wages of captain, engineers, firemen, stewards, porters, and crew, would obviously be far beyond those of the three or four men working the train by itself, and these, and all other working charges, would be divided, mile for mile, upon a very much less number of miles per annum than the number made by the train if run by itself. There would not, of course, be any permanent way charges with which to debit the boat, running on Nature's own highway, but as to capital charges, the interest upon the cost of the harbor works alone would probably be equal to that upon a railway costing £100,000 per mile. It is morally certain that a large Channel ferry, with a full complement of steamers, could be maintained only by a very decided advance in the fares, whether between the opposite coasts alone, or between London and Paris. Assuming that even as many as one hundred passengers were taken across in a single train, the capital charges and working expenses would probably amount to £20 per trip, assuming the boat to make 1,000 trips of 20 miles each per annum, and thus the charge per passenger would be 4s. for 20 miles, or nearly 3d. per mile. The carriage of goods, specie, etc., would lessen this rate, but it is as likely also that the average number of passengers per trip would be very much less than 100. Nor is it at all certain that each boat could make 4 trips daily for 250 days in the year. None of these reasons, however, patent as they are to the observation of all, are conclusive against the Channel ferry. On the contrary, the ferry is the only means of maintaining comparatively expeditious and comfortable communication, of which the absolute practicability is beyond all question, while it could be got to work within probably 2, 3, or at most 4 years, and at a cost, including harbors, of probably little more than £2,500,000.

That branch of the question which possesses real interest—surpassing interest of uncertainty—at least for the engineer, is that relating to a subaqueous way across the bottom of the Channel, or a regularly excavated tunnel 100 yds. or so deeper down in the gray chalk or clay itself. It is, perhaps, the certainty (the question of first cost being for the moment dismissed) that a tunnel, once made, would prove the very best of all means of crossing the Channel, and the qualified uncertainty whether such a tunnel is even practicable at all, that give to the tunnel its great, its even seductive interest to engineers. It need hardly be said that tunnels under water, or rather through the earth beneath the water, are anything but new or unusual. For very many years the tin miners of Botallack, in Cornwall, have driven their headings to a good distance beneath the very bed of the Atlantic itself. Just 60 years ago Trevithick nearly completed a tunnel beneath the Thames between Wapping and Rotherithe, and but for imprudently making a bore hole from the roof through to the river bed, this tunnel would no doubt have been successfully opened. Ralph Dodd had made the same attempt before. Brunel's world-famed tunnel requires no remark, and it will be but a few weeks before Mr. Barlow's tubular subway will be carried through from the Middlesex to the Surrey shore. The longest tunnel under water is that, two miles in length, of the water-works at Chicago, United States. This tunnel, although but 5 ft. in diameter, is carried out to where the water above it is 40 ft. deep, the tunnel itself being 30 ft. below the bed of Lake Michigan. There is also a tunnel under the Chicago river at the the same place. At home we have no less than 3 schemes for tunnelling beneath the Mersey, at Liverpool, and 3 for tunnelling beneath the Severn below Gloucester, and in both instances one of the 3 schemes

will in all probability be yet carried out. Provided only the bed of the channel or river beneath which the tunnel is to be made is nearly or quite impervious, under-water tunnelling is no more difficult than underground tunnelling. And there may be shafts, even, to under-water tunnels, just as the Chicago lake tunnel has its shaft through which the water supply is taken, but which was employed, during construction, for the ordinary purpose of giving a second working face and for discharging the excavated materials—this shaft being 2 miles from shore. This tunnel was carried through a continuous bed of tenacious clay, as impervious to water as marble itself. But in the proposed Channel tunnel, to be made at a depth of about 500 ft. beneath the surface of the sea, it is needless to remark that a single fissure in the chalk, however narrow, would be rapidly widened by the tremendous abrasion of water under the great pressure of 200 lbs. per sq. in.; so rapidly that probably no efforts to clear the workings could be expected to succeed. A fault of great vertical magnitude is well-known to divide the chalk beneath London, although neither the precise line of this fault, to within a few yards, nor the width, if any, to which the chalk bed is separated at the point, is known. Whatever may be inferred from the geological analogies of the chalk on the English and French coasts, it cannot for a moment be positively asserted that a fault beneath the middle of the Channel does not exist, nor, it is as well to add, can it be asserted, on the contrary, that a fault does exist. The question can only be settled by a trial heading or driftway; and, whatever the real danger, there are plenty of navvies and miners who, knowing no fear, are ready and willing to face it, when the eminent engineer, whose name is connected with the proposed undertaking, finds himself in a position to give the word. Let 2 headings, each 11 miles long, once be carried out to meet each other beneath mid-channel, and the success of the tunnel, so far as its completion is concerned, is assured. It would be a matter of long and tedious boring and blasting, and one in which uncertain millions would certainly be swallowed up, but it would all come right at last, supposing, of course, that by previous experiments upon that thirsty material, chalk, no excessive infiltration of water under a maximum pressure of 200 lbs. per sq. in. was found to take place, and there would be 24 acres of roof of each heading of 9 ft. in width, the ceiling, if it may be so termed, of each heading of 9 ft. width amounting to rather more than an acre per mile.

There are two distinct schemes for a tunnel beneath the bed of the Channel, but the same general certainties and uncertainties apply to both. It is only from geological inferences that either can claim superiority over the other. It would require space far beyond the limits of the present paper to deal even with the geological aspect of the question alone. It is but right, however, to remark that geological evidence, as far as it goes—for the materials at command are scanty—points strongly to the probability of the complete continuity and homogeneity of the chalk which forms the upper beds of the broad and shallow submarine valley separating our island from the Continent.

Bridging, steam-ferrying, and tunnelling fall within the ordinary range of engineering. But no engineer has yet attempted to lay down a railway upon the bottom of the sea itself—a railway, the passengers of which, like the Israelites of old, should go over, or, rather, under, dry-shod, not only with a dense wall of water on either side, but with 30 fathoms or so over their heads. It is not the purpose, here, to enter at length upon the relative advantages and disadvantages of subaqueous ways—a term employed merely to distinguish railways on the Channel bed from those in tunnels beneath it—as compared with railways deep down in the chalk. As, however, the remainder of the present paper will be chiefly devoted to the examination of the mode of constructing subaqueous ways, it will be but fair to enumerate the objections which may be urged against them. They are these :

Beyond some amount of uncertainty necessarily attaching to the laying of such ways, they might, possibly be injured by the dragging anchors of vessels, or broken in two by the sinking wreck of an iron steamer dropping upon them. They might, possibly, suffer at the shore ends, where they rose to within the action of the waves in heavy storms. They could always be destroyed wantonly, and with little fear of detection, by sinking a charge

of gunpowder upon them, at any portion of their length, and then firing the charge, at a safe distance, by electric wires. It might be urged, too, that a large tube, especially where it rose like a huge groyne, in-shore, might cause injurious disturbances in the Channel bed, thus affecting navigation. In any case, the tube could be started and carried forward from but one end only, as it would be out of the question to attempt to bring together, water-tight, the two closed ends, or for that matter the open ends, of two tubes in mid-channel.

These appear to be the principal, if not all, of the possible objections which could be urged against subaqueous ways. The weight of these objections depends probably more upon the individual opinions of those who advance or refute them than upon any evidence capable of demonstration. As for the dragging of anchors, the various proposals (and there are several) for tubes on the bed of the Channel provide for routes well off the Varne and Colbert banks, and, it need hardly be said, miles to the westward of the Goodwins; routes upon which vessels would seldom have occasion to anchor at all, even in the worst storms. Were an anchor dragged, however, with a force of even 150 tons —the highest chain cable test of Lloyd's proving house—this could not make any definite impression upon a continuous tube weighing 8 tons or more per foot of its length, for to move at all at least a quarter of a mile of tube weighing 10,000 tons would have to be dragged upon the Channel bottom. As for breaking the tube, say 4¼ in. thick of cast-iron with a lining of one foot of brick work, the chances would appear extremely improbable. But a greater security will appear when it is considered that a cast-iron tube, say 14 ft. in diameter, and having no outer flanges, presents no point upon which an anchor could bite. The chances of an iron vessel foundering exactly across the line of the tube are, to say the least, by no means numerous. In shore, that is to say in shoal water, the tube would require to be protected by strong parallel breakwaters, as much to prevent vessels grounding across it as to prevent the action of the waves upon it. The risk of possible destruction by malice—the crushing in of the crown of the tube by the explosion of gunpowder upon it in 10, 20, or 30 fathoms of water—is a risk of which each one must form his own estimate. This mode of destruction, the consequences of which would be irreparable for all time, could most certainly be resorted to by hostile or merely malicious feeling, with almost no chance at all of detection, whereas neither a bridge nor a tunnel deep down in the chalk could be destroyed without some difficulty, and the certainty of the timely discovery of the attempt.

The various proposals for laying subaqueous ways upon the bed of the Channel are as distinct from the ordinary range of bridge and tunnel engineering as the making and laying of submarine cables are distinct from the construction of land telegraph lines. Of what is technically distinguished as mechanical engineering, very little is now required for the construction of an iron bridge, or a tunnel in earth or rock; but the construction and laying of a subaqueous way would be, to a large extent, the work of the mechanical engineer. Such a work, upon any plan, would be one attended with many contingencies, and so far as mere ingenuity is concerned (not that the necessity for greater ingenuity is in itself an objection) the subaqueous way would incontestably require far more originality of design, for its making and laying, than any other mode whatever of crossing the Channel. But as engineers always rise to the occasion, it may be assumed that a plan, physically possible in the abstract, would never fall through from the want of that elaboration and improvement which are summed up in the mind of the engineer in the single word "detail."

Perhaps the first quasi practicable plan proposed for crossing the English Channel by means of a subaqueous way was that contained in an anonymous pamphlet printed in Dublin in 1858. The author proposed to construct a 15 ft. tube from Dover to Calais, extending it, foot by foot, along the bed of the Channel, from the English to the French coast. Starting from the English coast, within a structure named a "head" or a "bell," this head fitting water-tight, around the exterior of the tube to be extended, he proposed to put together each successive length of the tube within the head, and to push the latter forward as fast as the work proceeded, the head meanwhile

lying on the bed of the Channel. The calculations of resistance, and of the quantities to be employed in the tube itself, were carefully worked out, and so far as the author has tested them, these calculations were correct upon the *data* assumed. This mode of construction insures the advantage, if it be an advantage, that each portion, whether of 10 ft. or even a mile, of the length of the tube, once laid, is not again disturbed at any subsequent stage of the work. But the designer appears to have foreseen an element of possible weakness when he asserted that even were the tube rolled over in the Channel no harm could result to the passengers, and no interruption to the train service. Inasmuch as the atmospheric system was relied upon for propulsion, and the passenger compartments were to be shot through circular tubes, it might not perhaps make any difference to the passengers whether their carriages bottomed upon one part of the tube or another; but it would be interesting to know what would become of the shore ends, and for that matter, the passengers themselves within the tube, if a few miles of the latter were really to turn over in mid-channel.

The anonymous idea of 1858 has been lately worked out in much greater detail by an eminent English engineer, whose labors have been assisted by an Austrian member of the same profession. Their plan, which has now been for some weeks before the public, provides for a cast-iron tube of 13 ft. internal diameter and 4 in. thickness, to be carried out in 10 ft. lengths, each length being formed of six segments. The work of putting together the successive lengths of the tube is to be performed on the bottom of the Channel, within a cast-iron "bell," as it is termed, this "bell," or shield, being 80 ft. long, 18 ft. in diameter, and 8 ins. thick. The tube is to be packed, water-tight, within this bell, and the bell itself is to be forced forward, 10 ft. at a time, after that length of tube has been added to the portion already laid. For forcing forward the bell 4 hydraulic presses, each of a maximum force of 1,000 tons, are to be employed. The details of the scheme are most ingenious ; at the same time perhaps not too much so, for many a mechanical project has been ruined by too much ingenuity. It is evident that from the very confined space, but a dozen men or so at most could be effectively employed at a time within the end of the tube, in putting the segments together, although a much larger number, were they required merely to work the hydraulic machinery, could find room in the forward portion of the "bell," and it is evident that the rate of progress of the tube would be measured by the rate of working of the dozen or so of men employed in putting the segments together, the segments being brought, when the tube was nearly completed, from a distance of say 20 miles through the tube itself. The segments and bolts once made ready on shore, the whole labor of putting the tube together, the whole task of maintaining its intended course, and the whole of the responsible duty of inspection as the work goes on, would be performed under water, in an artificial light, and with artificial ventilation, and where, upon the occurrence of any accident, causing the sudden inroad of water, all within the tube must hopelessly perish. Should the tube crack and fill with water during the process of laying, it is also hopelessly lost, since no moorings are or can be attached to it during the process of laying or afterwards. That the tube might crack, at some point, while the shield was being advanced under a force, according to the depth and the nature of the bottom, of from 1,000 to 4,000 tons, would be nothing very improbable. And what might be the chances of leakage, with nearly 65,000 joints made in the dark, or, rather, in a very feeble light, and under water, must be left to the imagination, the joints themselves being upwards of 200 miles in aggregate length, and, taking them as 8 ins. wide each, presenting a total surface, for the two parts brought together, at each joint of about 34 acres. There is, probably, nothing physically impossible in the scheme, although it would be one attended with many improbabilities of success. Nor could this plan of construction be adapted to the irregularities of the Channel bottom, upon which the gradient would occasionally require to change from level to 1 in 100, making a difference of $1\frac{1}{2}$ in. between the joints on the upper and lower sides of the tube, thus necessitating special castings, or involving the risk of leaking. The particular tube now under consideration would have a multitude

of external flanges, and it is not improbable that it might suffer from dragging anchors. These flanges and ribs are not essential, however, to the general plan.

While it is fairly open to doubt whether any of us will ever live to see a practical railway tube laid across the Channel—open to doubt, too, whether such a tube is even required at all—there is still a sort of bewitching interest in speculating upon the mere possibility of such a thing; and it is thus that this meeting may be supposed to have resolved itself into a committee of inquiry upon this very point. Can the tube be made at all? Can it be made before those now unmarried shall have lived to see their grandchildren? If it can be done, and done off hand, so much the better, always provided that the tube is what is wanted. Here, as with Mr. Midshipman Easy, there is no help for it but to "argue the point." Assuming, then, for the sake of argument, that the particular tube now under consideration can be made, and safely laid, can it be done, as its proposers estimate, within a period of three years and a half, or only within from six to ten times that space? The tube is to be made of something like half a million tons of cast-iron, and to believe that it can be made at the rate of 100 ft. forward a day, as estimated, is to believe that nearly 500 tons of castings, all ready, or, rather, *supposed* to be ready, to go exactly together, each casting weighing about 8 tons, can be loaded on horse trucks, or hand trucks, and carried through the tube itself for an average distance of ten miles, unloaded, placed in position, the thousand or more connecting bolts, for which the holes have been previously drilled, secure in their places, the joints made good with lead, and a great deal of other work carried on, all within a confined space, within which, partly from the machinery to be employed, hardly more than a dozen men, if as many, will have room to work at all. The British Association was lately occupied with a most able and most interesting description of this plan, and the Society of Arts may therefore be inclined to examine this, the very important point, which, at the recent meeting of the Association at Exeter, appears to have escaped all examination whatever. The "point" might be "argued" still further, but let argument be dropped now for individual consideration of the subject.

Another plan of making and laying the tube has been proposed—a plan based, like the others, upon a general estimation of what is possible and probable. It is to construct the tube, in long lengths, within a dry dock in shore, and to float out these lengths, successively joined together, until the opposite coast is reached. The tube would be floated—not, certainly, upon the surface, but by means of buoys, just clear of the bottom, the tube being again grounded as soon as it had been advanced a length.

Few propositions, perhaps, connected with engineering, upon which the writer has ever reflected, have, at the first view, presented more apparent impracticabilities than this one. But the more he has examined it, the more have the means by which these difficulties may be overcome, disclosed themselves. It was enough to know, from the first, that the plan was not in contravention of any law of nature, and therefore was not impossible. Like each of the other plans already noticed, its execution would necessarily be in the face of tremendous difficulties—difficulties which, perhaps, not one of the various projectors of channel tubes have fully estimated, and which, it is beyond doubt, they have not, because they cannot have, fully provided for. But the whole progress of engineering has shown that what were once seeming impossibilities have long since become useful and familiar facts. The difficulties supposed to be once overcome, it is plain that a plan whereby, say a thousand feet or more of the tube could be put together in a single day, in the open air, as many men being employed upon it at once as could find room to work with advantage upon that length, would have a manifest superiority over any other in which each length of a few feet, say ten, must be wholly completed before another length could be begun, and especially in which the whole work of making up the tube is to be carried on within the tube itself, the parts being brought to the front in trucks drawn by horses to a distance successively increasing to twenty miles.

In no way could the segments of a tube be so rapidly got into place and secured together as in a dry dock, the semi-circular bottom of which, of cast-iron, would conform exactly to the tube itself. The seg-

ments would be lowered into place, those for the lower half of the tube centring themselves, while those for the upper half would be temporarily supported upon centres so made as to be readily taken down when the key segment was got in and secured. The seaward end of the tube, of great strength, would, of course, be closed, and it would be provided with suitable fittings for attaching the powerful hauling-out tackle, to be used when the successive lengths were floated. The dock gates would close around the tube so as to form a water-tight joint. The tube would be of such dimensions and thickness that, previous to putting in the brick lining, its own weight would be, as nearly as possible, exactly the same as that of the sea water displaced, so that of itself it would, so to speak, neither sink nor swim. Approximately, a 14 ft. tube would displace about 4½ tons of water for each foot of its length, and it would of itself weigh about 4¼ tons for each foot of its length when its thickness, allowing for all flanges and bolts, was 5 in., or say 4½ in. between flanges, and this would be the proper thickness for strength, irrespective of any consideration of displacement. The weight of the tube would require to be very accurately adjusted, since a difference of thickness of 1 in. would cause a difference of weight of 900 tons in a 1,000 feet length, hence a difference of but $\frac{1}{1000}$ of an inch would represent very nearly a ton in weight. Each length would require to be brought to the exact limit of flotation by means of adjustable weights. As the tube would require to be adapted to the irregularities of the bed of the channel, each length of a thousand or more feet, would have a ball and socket joint, and it would be here, and here only, that the sinking weight would be applied, and the holdfasts for the lifting and sinking tackle attached. Probably 100 tons might be necessary to prevent any movement of the tube, especially in-shore, from the force of the sea, for at a depth of a few fathoms the force of storms would not be felt at all. The tube being made in segments, the construction of ball and socket joints would be attended with no difficulty. They would require to be made of great strength, not merely to provide sinking weight, for they would receive the whole strain of the hauling-out tackle when the tube was advanced seaward. A thickness, for the ball and socket, of 8 in., this thickness being continued a lttttle more than 10 ft. each way, would give 100 tons of sinking weight. The motion at these joints would be but slight; yet this slight amount of motion is none the less necessary to enable the tube to adapt itself to varying gradients. It is at least remarkable that any strictly rigid tube should ever have been proposed, as more than one has been, for a line having gradients varying from nearly level to 1 in 100.

When a length of tube had been completed and was ready for launching, its in-shore end would be closed water-tight, the buoys made fast in place, the dock gates opened, and the sea admitted, upon which the tube would be drawn up well clear of the bottom by means of the adjustable tackle connected with the buoys, and the whole of the tube, of whatever number of connected lengths of 1,000 ft., would be drawn out to sea for a distance corresponding to the length last added. It would then be lowered again upon the bottom, the in-shore end of the tube being left well within the dock gates, which would then be closed, and the water in the dock pumped out.

In buoying and advancing the tube, especially when extended nearly 20 miles, it contained nearly half a million tons of cast-iron, the chief resistance, in starting, would be, occasioned by, not its weight—for except at the ball joints it would have no preponderating weight in the water—nor by its skin friction, for this at a rate of motion of 1000 ft. only in an hour would be comparatively trifling; but the real resistance would be from inertia. It might be supposed that as much effect would be produced by the hauliing-out-tackle if made fast to the Rock of Gibraltar as if to a great iron sea-serpent, 20 miles long, and weighing half a million tons. But let us see what this enormous resistance would be. Let the rate of onward motion of the tube be 3 ins. per second, a rate at which 100 ft. would be gained in 400 seconds, or 1 hr. 6 mins. and 40 secs.; not so very long a time after all. To give this rate of motion would require the same force as would be necessary to lift the whole weight to a height of the $\frac{1}{88}$th part of an inch, a distance almost too insignificant to deserve consideration until it is understood that 500,000 tons are to be lifted to that height. It is then that

the $\frac{1}{8}$th part of an inch begins to look respectable, the work done being equal to that in lifting 1 ton to a height of nearly 500 ft., or, in other words, 500 foot-tons, which is about the energy contained in a 32 lb. cannon ball when it leaves the gun fired with a full service charge. But these 500 foot-tons do not need to be exerted within 1, 2, or 3 mins., and if a quarter of an hour be taken to get the sea-serpent under weigh, the mean rate of progress during that time being $1\frac{1}{2}$ in. only per second, the tube will have progressed $112\frac{1}{2}$ ft. before it is in full swing, and thus the pull will average less than 4 tons during that time, after which all further resistance from inertia ceases. Now 4 tons is a little more than the breaking strength of the little Atlantic cable of 1858, and is well within the working strength of the steel wire ropes employed to haul Fowler's steam ploughs. Next comes the resistance of skin friction. The surface of the tube, supposing it to be 14 ft. in diameter and 20 miles long, and having no outer flanges, would be nearly 107 acres, whereas a ship like the Hercules has but little more than three-quarters of an acre of immersed surface when ready for sea. But the Hercules has run nearly 15 knots an hour with a net thrust upon her screw shaft of about 50 tons, the resistance being nearly all skin friction only. Skin friction is believed to increase as the square of the velocity, so that the 1,000 ft. an hour of the sea-serpent are to be compared to the 90,000 ft. an hour of the Hercules, not in the proportion of 1 to 90, but in that of the square of 1 to the square of 90, or as 1 to 8,100. Thus the Hercules, weighing 8,600 tons, requires 50 tons pressure at the stern to drive her at her full pace, while the serpent, with a skin nearly 150 times more expansive, and a weight nearly 60 times greater, would nevertheless, upon the law of the square, require a pull of less than 1 ton to tow it by the nose, if serpents have noses, all the way across the Channel, its inertia having been already overcome. And yet this mass of iron, if thrown into the form of a cube, would measure about 136 ft. on a side.

That the tube would follow its nose, in a straight line, and not in the zig-zag outline of a Vandyke border, known in America as the Virginia fence pattern, may be safely concluded, not only from a consideration of the reasons which would compel it of necessity to follow a straight course, but from an analogy afforded by Mr. Macsweeny's jointed steamboat, the Connector, which plied a few years ago between Newcastle and London, and by Mr. John Bourne's trains of connected boats on the Indus. Although neither of these systems proved commercially successful, both demonstrated that a long train of boats connected together will follow as true a course upon water as will a long train of wagons on a railway.

The tube would be hauled forward as each fresh length was added, by tackle worked from a vessel steered well ahead, on the true course, and there moored fore and aft, to prevent swinging out of her position, although the whole work of advancing the tube would or should be performed at slack high water. In such a great work, so important to the commercial interests of the whole world, it is not unreasonable to suppose that a convention would be entered into by all, or nearly all, commercial nations sanctioning the authority of a marine police to guard the hauling chain from dragging anchors.

But now come, perhaps, the principal questions of all. The maximum tidal current, at spring tides, in that part of the Channel where the various proposed tubes are intended to be laid, is, by Burwood's Tables, 3.3 knots an hour, or 5.57 ft. per second. This is, however, the surface velocity in mid-channel. The velocity at the bottom, in the deeper portions, is probably *nil*. In a communication recently made public by Mr. Cromwell Varley, the eminent telegraph engineer and electrician, occurs the following interesting and even amusing passage:

"It is well known to all nautical men, that the action of the waves decreases very rapidly in descending. I believe I am correct in stating, in proof of this, that a diver, engaged upon the wreck of the Royal George, accidentally left his spectacles on the wreck off Spithead. The depth of water was about 16 fathoms. A violent storm prevented him from resuming operations for about 9 days, and, on again descending, he found his spectacles in the place were he left them.

"It is also well known to all nautical men, that currents extend, as a rule, to only a small depth; and it is a common practice to moor a boat in deep water, by tying a kettle or some heavy object to

a line, and dropping it overboard into the comparatively still water. This mode of anchoring has been frequently used by the surveyors in the Atlantic.

"As a further proof of the complete stillness at the bottom, I may mention the cable that was laid from Varna to Balaclava. This plain gutta-percha covered wire was wholly uninjured by those terrific storms which destroyed so many English vessels."

With 100 tons of anchoring weight at the shore end, and with the same weight at distances of every 1,000 ft., and with the immense inertia of a tube weighing 4,500 tons between each pair of sinking weights, there would appear to be but little danger from the action of storms—a conclusion borne out by the fact that iron sewer pipes are often extended well out to sea, as at Brighton, and remain there without disturbance. The waves come end-on with the tube, and are harmlessly divided, whereas, did they strike it athwart, they would lift it upon the beach. Experiment, during a single winter, would determine whether even so much as 100 tons sinking weight would be required at each 1,000 ft. It might turn out that 50 or even 25 tons would suffice, in which case the work of lifting and grounding the tube, as about to be described, would be very greatly lessened. The most critical point in the whole scheme is probably that of lifting and lowering the tube at each advance. Before going into this, it will be as well to see what is to be done at each sinking weight or ball joint in deep water, say 33 fathoms at high tide. There are 100 tons of dead weight to be lifted, besides the inertia of 1,000 ft. of tube to be overcome, and there is also the weight of the lifting chain itself, and its supporting buoy. Taking the weight and inertia to be overcome as 150 tons, and supposing the lifting chain never to be strained beyond 3 tons per sq. in., the sectional area of the chain would be 50 sq. in., so that each 15 ft. of its length would weigh a ton. As the chain would commence two fathoms and a half from the bottom, we will allow that for slack, and its own weight would thus be between 13 and 14 tons. This it would be necessary to buoy with the utmost care, for, once lost, the chain could never be recovered in water of greater depth at most than 15 fathoms. The buoy, weighing probably 5 tons of itself, should have at least 20 tons of additional supporting power, and would thus require to be of a capacity of 875 cubic ft., corresponding to a cylinder 8 ft. in diameter and 18 ft. long. Were it not that the buoys must be kept out of the way when the lifting tackle is attached, they would be best secured by passing the chain through them in the central pipe with secure stoppers, top and bottom. As they would, in any case, continue to float, this might, after all, be the best way of attaching them, when the stoppers were taken off at each lifting and lowering.

In getting into deeper water the chains would require to be lengthened, in 10 ft. lengths, at every few advances, and in shoaling they would also have to be shortened in proportion. The lifting and lowering would be performed from a vessel alongside, and the lifting itself be effected by steam, acting directly upon the lifting chain; that is to say, a strong steam cylinder 5 ft. in diameter, and permitting of a stroke of piston of 20 ft., would be supplied with steam from a small boiler worked at from 125 lbs. to 150 lbs. per sq. in., giving a lifting force of from 150 to nearly 200 tons. It is only by a direct steam lift that the effects of pitching and descending in the lifting vessel, and the varying level of the sea as the tide ebbs or flows, can be provided against, and that the elasticity of strain, necessary for the preservation of the chain, and thus of the tube itself, could be secured. There are many details which would require to be carefully worked out before such an undertaking could be safely begun, but, without entering at greater length upon them here, it may be said that the principles upon which safety at each step would be reasonably assured have been considered with some care, and that there are no difficulties in the way which appear really insurmountable. It is not to be forgotten that a lifting vessel would be required at each 1,000 ft. length, making no less than 110 in a length of 21 miles. There would be no difficulty in chartering the number, and the cost of the requisite fitting would not, in comparison with the whole cost of the work, be excessive.

The practicability of this making and laying a tube could be approximately ascertained by making two 500 ft. lengths of tube half size, or 7 ft. diameter and 2½ in. thick, closing their ends, and sinking

and lifting them by means of 3 tug boats in different parts of the Channel. These lengths would weigh, including sinking weights, about 925 tons. If the experiment succeeded perfectly, as it should, in calm weather and at slack high water, it might be continued in rough weather and under the influence of the tidal current. The exposure of one or both these lengths, for a single winter, lying end-on to the shore, would afford very valuable experience. It is always to be borne in mind that after the tube is once laid, the brick-work lining and permanent way which will then be added will more than double its weight.

The tube, when laid for its whole length, would be bolted together at the ball joints by means of inner flanges, the whole then lined with brick-work and an inner iron casing, a permanent way laid, and would then be worked upon the atmospheric system.

The cost of the whole may be roughly estimated as follows:

500,000 tons of castings fitted ready for placing at £6	£3,000,000
Brick-work lining	250,000
Dry dock, fixed plant, etc.	500,000
Floating establishment	1,000,000
2,500 workmen for two years at £100 per annum	500,000
Interest, during construction	500,000
Engineering and contingencies	250,000
Total, exclusive of approaches	£6,000,000

The plan suggested can claim no other advantages than these, viz.: its practicability being assumed, it could be carried out in two or three years, including all the time expended in preparatory works. Almost any number of workmen might be effectively employed at the same time, and that in the open air, in full daylight, and out of the way of danger in case of accident. The tube would furthermore possess a flexibility which would insure its following the irregularities, both vertical and lateral, which, with a careful survey in advance of the work, would naturally be found even on the comparatively smooth bed of the Channel.

It forms no part of the objects of the present paper, however, to put forward claims in favor of submerged railways. It is admitted, on all sides, that they cannot be made at a less cost than from £300,000 to £500,000 per mile. It is by no means certain that, even for the saving of half an hour and an immunity from seasickness, the majority of passengers would prefer a submarine journey of three-quarters of an hour, with the knowledge that but a few inches of iron were interposed between them and a second deluge. The fact that almost countless fleets of shipping were crossing 50 or 60 yards overhead; that a single ship, foundering then and there, and making its fatal plunge upon the tube, might work even greater destruction than its own; the reflection that scoundrels in the pursuit of mischief, or villains in the service of the devil, could at any time, and with almost perfect impunity, dispose of the tube for ever—all this would be anything but reassuring to the timid, and it would have its due weight with the strong.

In respect of economy merely, the interest upon a cost of £6,000,000, supposing the work to be carried out for that sum, and the money raised upon the guarantee of the English and French Governments at 4 per cent., would be £665 per day, or £231 per mile per week. It is not, perhaps, necessary, however, to assume that the work is to be undertaken as an immediately paying speculation, since other considerations of importance are involved in the question.

It is not to be lost sight of, however remote the bearing of the question upon the present subject may appear to be, that a sudden demand, within a couple of years, for half a million tons of cast-iron, not for export, and not for immediately productive employment at home, would most certainly inflate the iron trade, and, indirectly, affect nearly every branch of our industry. If the price of pig-iron advanced, as it not unlikely might, to the extent of 20s. a ton, this means 25s. or 28s. on rails, 30s. to 35s. on bars, and from £2 to £3, or even £4, on the higher qualities and lighter sections of iron. The very home demand, whereby we would be literally throwing our iron, and with it our money, into the sea, to no immediate profit, would give to other nations an advantage of which they would not be slow to avail themselves. Half a million tons of pig iron, when converted into rails, bars, or plates, and allowing for loss in conversion, would suffice for 2,000 miles of double line railway, or it would construct 75 miles of heavy iron bridges, weighing a ton per foot, or it would serve the shipbuilder for 250 hulls, such

as, when fitted, would register their 3,000 tons each. The sudden abstraction of such a quantity for a single work, having no immediate prospect of success, might be attended with consequences which the whole country would long have occasion to deplore.

It has been mainly the object of the present paper, however, to examine into the engineering merits of the various schemes proposed for crossing the Channel, and the writer cannot close without expressing the belief that the balance of certainty, economy, and, all things considered, the safety and even the comfort of the travelling public remains with a large and suitably organized Channel ferry service.

HYDRAULIC MACHINERY FOR WAREHOUSING GRAIN.

By Mr. PERCY G. B. WESTMACOTT.

From "The Mechanics' Magazine."

The subject of the paper of which the following is an abstract was a description of the hydraulic machinery for warehousing grain at the Liverpool Docks. Blocks of warehouses have been erected by the Mersey Dock and Harbor Board, ably designed and executed under the supervision of Mr. Lyster, the dock engineer, for the stowing and conditioning of grain and bread stuffs. The dock upon which they are situated is 570 ft. wide by 230 ft. broad at one end and 180 ft. at the other, with a depth at high water spring tides of 34 ft. over the sill of the gate. The blocks on the east and west sides of the dock are 650 ft. long, and that on the north end 185 ft., the whole range being 70 ft. wide. The buildings contain five stories. Above the fifth or upper storage floor, and partly in the roof, is placed the machinery floor, and below the quay level are wells and arched subways for the reception of the underground machinery. The total storage capacity of the floors, exclusive of the quay floor (at 4 qrs. to the square yard) amounts to 196,000 qrs. of grain. The ends of the east and west blocks are constructed to receive iron chambers for conditioning grain on the Deveraux system, in order to prepare it for the market by drying. The steam-engine, the prime mover of the whole plant of machinery, was of 370-horse power, and that, in addition to driving the machinery in the warehouse, supplied power for working the lock machinery and the bridge over the entrance, consisting of two 60 ft. and one 50 ft. bridges, twelve sluices, ten powerful ship capstans, and twenty-four machines for opening and closing the lock gates. From returns taken of the importation into Liverpool of the different descriptions of breadstuffs for the years 1858–63, it was estimated that the warehouses should be constructed capable of working 250,000 tons per annum, irrespective of other ordinary merchandise.

Having described the principal processes required to be performed by the machinery, and the best means likely to secure the requisite power, and especially the kind of power, and the most convenient, practical, and least costly method of applying and distributing that power, the writer stated that it was found after experiment that no system of motive power, or combination of systems, could be found to meet those requirements in the aggregate with so much effect, convenience, and economy as the hydraulic system. Having noticed the facility with which this power had been conveyed for long distances at the Birkenhead docks, and also the advantages, or otherwise, of propelling grain horizontally by means of screws, the author stated the results of the latter system. At sixty revolutions per minute (the maximum effective speed) grain could be discharged by a screw in use at a certain brewery at the rate of $6\frac{3}{4}$ tons per hour, being at the rate of $\frac{1}{25}$th-horse power for every foot run. With a screw subsequently put into operation of 12 in. diameter, and driven at the rate of seventy revolutions per minute (the most effective speed), thirty-four tons of grain per hour were discharged. The effect upon the grain in the latter case was marked, it being rubbed and polished, and thereby improved in marketable condition. But the long distance through which the grain had to be conveyed horizontally, amount-

ing collectively to 7,000 ft., and the power required to perform the operation, even with the best form of screw, rendered it expedient to seek some other method less absorbent of power, and recourse was had to endless travelling bands.

Experiments were made with a 12 in. band, constructed of canvas and india-rubber. It was found that a speed of 9 ft. per second could be attained with heavy grain, and still more with peas. The amount of grain discharged by the 12 in. band at the speed of 8 ft. per second, was at the rate of about 35 tons per hour. Further trials were carried on with an 18 in. band, made of 2 plies of stout canvas, covered with vulcanized india-rubber. To meet the requirements of passing grain from off the straight bands to either side at certain points along the travel, several contrivances with air blast, and brushes driven from the band itself, were tried, but with indifferent success. Both methods were objectionable on account of raising dust, and the friction of the brush proved in time injurious to the band. The idea then occurred of diverting the line of the current of grain by means of an upward deflection of the band, thus casting the grain clear from the band into the air for a short distance; it could then be received upon a band travelling in any other direction, and, if necessary, could be passed round the warehouse from one side to the other, or even make a circuit of three sides of the block, according to the method in which it was intended to dispose of it, or the place in which it was to be deposited. There were 56 spouts, 8¼ in. square, from the upper to the various other floors. No difficulty was experienced in keeping the grain on the band, but it was found necessary to glide the grain on to it from the feeding hopper through a spout rather less than half the breadth of the band, at an inclination of 42½ deg., which would impart a velocity to it of falling approximating to that of the band. The maximum amount of heavy grain conveyed by the 18 in. band was at the rate of 70 tons per hour; the power required for driving the band when fully loaded was ascertained to be equal to about $\frac{1}{70}$th-horse power effective per foot run.

The paper then described the boiler and engine, etc., and also other apparatus with which the warehouses are furnished, including the cranes and the two accumulators, each of which latter is weighted with a load of 70 tons, acting on a ram 17 in. diameter, and the auxiliary accumulator with a load of 100 tons, acting on a 20 in. ram. The form of tub in which grain is lifted from the hold of ships, and the hoppers through which it is passed for various purposes, having been minutely described, the author detailed the construction and capacity of the elevator, which consists of a wrought-iron bucket, capable of containing about 21 cwt. of grain. It was slung in an arrangement of bars and levers, provided with guiding rollers, which enabled the bucket to run in special grooves to the top, for the discharge of the grain into the upper hopper, which communicates with the same cross bands that convey the grain from the hopper under the crane. Casks, bags, and other merchandise might be raised or lowered by two classes of machine—one by means of the hydraulic cradle hoists, of which there were 12; the other by means of 20 jiggers. Twelve double-acting 10 cwt. jiggers had also been added to the plant in the central block, to lift and lower goods to and from railway wagons. The paper lastly directed attention to one of the great advantages which the hydraulic system possessed in so eminent a degree, namely, the facility afforded for the extension of power to any point where the demand for additional contrivances to save time and hand labor was felt.

According to official statistics, 158 accidents occurred on Prussian railways in 1867. The train ran off the rails 206 times, there were 68 collisions, 432 times the carriages or engine were injured, 9 persons travelling on the train were killed, and 21 in other ways, while 68 were more or less seriously injured. The causes of the accidents were as follows: 124 arose from the state of the atmosphere, snow, fog, wind, etc., 25 from accidental obstacles on the line, 4 from obstacles intentionally placed there, 11 from the carelessness of officials, 60 from the mistakes of engine drivers, and 41 from the bad state of the line. The rest were the results of faults in the locomotives, carriages, etc., or of undiscovered causes.

THE RANSOME PROCESS.

From "Engineering."

Almost every one is familiar with the ordinary process by which Mr. Frederick Ransome manufactures artificial stone, and knows how the sand, mixed with silicate of soda, is treated, then with chloride of calcium, with the result of their mutual decomposition and reformation as silicate of lime and chloride of sodium, the former living as an indestructible bond throughout the stone, the latter soluble and easily removed. The sand, after being dried, is worked up in a mill with the soluble silicate brewed from caustic soda and flints, the latter being dissolved by the former, and evaporated down to a specific gravity of 1.700. The plastic mass thus produced is obedient to the will of the moulder, and can be manipulated into any form, from a cube to elaborate screens, such as those decorating the India Office; from a grindstone to an exquisitely chiselled fountain, like that recently erected in the public gardens at Hong Kong. The mass so prepared is then saturated with chloride of calcium, applied either simply by immersion, or assisted by the action of an air pump, in either process the solution being gradually heated to a temperature of 212 deg. Fahr. Mr. Ransome has recently made some further important improvements, which promise great results.

These consist, first, in submitting the moulded mass to the indurating action of the chloride solution at a higher temperature in closed chambers connected with a steam boiler. When this has been carried on for a sufficient length of time, by opening a cock, the solution is forced by steam pressure into a separate chamber, leaving the stone to cool gradually in partial vacuo, by which all dangers of cracking is avoided—a casualty which is liable to happen when large masses are exposed to rapid extremes of temperature in the open air.

The next feature in these improvements lies in the ingenious method adopted by the inventor for extracting the soluble salts of calcium and sodium from the body of the stone, which is effected in the same closed chamber by the admission of steam (or steam and water alternately), which, as it condenses and becomes saturated with the salts referred to, is returned into the boiler, where the steam is generated, and the chloride of calcium is again made available for future operations, thus obviating the serious loss incurred by washing the stone in the way hitherto adopted.

It is gratifying to learn that the manufacture of this stone is being adopted even in most distant parts of the globe. We have already, in previous notices, informed our readers that manufactories have been established for its production in India, America, Australia, Belgium, Denmark, and Sweden. But little actual progress has, however, been made in the practical introduction of the Ransome process in the United States. It is true that the patent rights for that country were advantageously disposed of some years since, and that the proprietor in America has made capital by the sale of licenses; but ignorance or indifference, on the part of the original purchaser, prevented his licensees from developing a large and most lucrative branch of industry. This being the case, it is satisfactory to find that one of the would-be manufacturers in the United States has taken the initiative, and is endeavoring to redeem the time lost and the capital expended in useless experiments. The proprietors of the patent right for the State of California have established large works in San Francisco, under the title of the Pacific Stone Company, for the production of artificial stone, and, but for the slight drawback of being in ignorance of the practical details of the process, would probably have developed an extensive business. Being unable to obtain the necessary information from the American proprietor, and tired of working in the dark, they have at last adopted the most satisfactory and common-sense course of coming from California to Greenwich to learn the whole course of the manufacture at the fountain head. To this end the managing director, and principal shareholder in the Pacific Stone Company, Dr. W. May, has recently arrived from California, and is rapidly acquiring the mysteries of artificial stone manufacture from Mr. Frederick Ransome, by whom every facility is offered for the benefit of American licensees. We

mention this because it is a matter much to be regretted that for so long a time the vastly important Ransome process should have remained almost a dead letter in the States, so far as real utility is concerned; the American proprietor having apparently devoted his attention to making money rather than stone, from his purchased patent right. This is, of course, at an end now, and the manufacture under this patent in America will be so much greater than it is in England as the demand for the production is proportionately increased.

THE HOLSTEIN INTERMARITIME CANAL.

From "The Building News."

EARLY ATTEMPTS FOR DIRECT INTERMARITIME COMMUNICATION.

The idea of constructing ship canals across narrow strips of land, for promoting commerce, is (according to an American contemporary) not new. From a work of Antonio Galvo, entitled "Tratado dos Descubrimentos," we note the fact that the opening of a ship canal between the Atlantic and the Pacific Oceans—"the mightiest event, probably, in favor of the peaceful intercourse of nations which the physical circumstances of the globe present to the enterprise of man"—was proposed to Charles the Fifth in 1528. And, strange as it may seem, the inquiries instituted at that time, led to the recommendation of the same lines that were planned in 1825. Still older is the project of the opening of a ship canal across the Isthmus of Corinth in the Mediterranean. It engaged the attention of Periander, Demetrius, Julius Cæsar, Caligula, Herodes, and Atticus, but it was reserved for Nero to take the first active step toward the accomplishment of this end. He completed a canal half-way, as lately ascertained by the explorations of the learned Frenchman, Mons. Grimaud de Caux. This isthmus connects the peninsula of Morea with the province of Attica, in Greece. By means of a canal cutting through this narrow strip of land, the route from the Ionian Sea to the Archipelago would be considerably shortened. Such a canal would be of great importance, as enormous quantities of grain are exported from the borders of the Black Sea to the seaports of the Adriatic.

The project of uniting the Baltic with the North Sea by a navigable ship canal dates from the zenith of Lubeck's commercial prosperity, and was suggested first as early as 1390. This project occupies at the present moment the attention of the North German Parliament, and, being one that may safely be ranked among the gigantic engineering enterprises of the present age, we have endeavored to collect such accurate knowledge with regard thereto as existing sources admit.

WHY THE PROJECT WAS STARTED.

Two reasons call peremptorily for the accomplishment of a navigable route between the North Sea and the Baltic, to wit: gain in time, and safety. The distance between the English canal to the open Baltic Sea around the promontory of Skagen is about 880 miles. It would be shortened for two-fifths of its whole length if a straight route from one shore of Holstein to the other could be chosen. Steamers would thus be enabled to make the voyage from London to St. Petersburg in five days, instead of seven, while sailing vessels would gain from one week to one month, according to circumstances.

The second reason for the building of a ship canal is still more important. According to even very incomplete statistical data, the annual number of losses of vessels in that portion of the sea is greater than that of any other equally large portion of the globe. This is the more to be deplored as the route around Cape Skagen is the only one from the North Sea to the coasts of Sweden and Finland, as well to the very heart of Russia. Indeed, it has been ascertained that the yearly loss experienced on the old sea-way amounts to three million rix dollars, or about two million dollars in gold. This sum is certainly a large one, but it must be remembered that the cargoes of many vessels are exceedingly valuable. For instance, the cargoes of the American barque Joseph

Clark and the English steamer Arctic amounted to half a million dollars in gold; the former vessel was shipwrecked in 1857, and the latter in 1860. These accidents mainly occur on the western coast, especially on the sand banks of Skagen, which for this reason has been denominated "the graveyard of ships." Indeed, small and large wrecks are seen there in every condition and at every time of the year.

It may now be remarked that there are now two channels across the isthmus of Holstein; they are, however, altogether inadequate to the existing demands of navigation. The one is the so-called Strekenitz canal, begun in 1390, and completed in 1398. It is one of the oldest in Europe, and connects the river Elbe with the Trave, uniting with the former just above Lauenburg, and with the latter about Lubeck. The second artificial water communication is known under the name of Schleswich-Holstein, or Eyder Canal, and may be found on any good map.

THE PROPOSED LINE.

This has been submitted to the world in the form of an anonymously published pamphlet, entitled "The Cutting of the Isthmus of Holstein between the Baltic and the North Sea." Lubeck is proposed as the eastern terminus of this route, while it is thought that the most feasible point for the western terminus would be Gluckstadt, upon the Elbe. This line, as shown by accurate and reliable surveys, would require no locks. It is proposed to follow the river Trave from Lubeck to a point where it approaches the Hemmelsdorf Lake. This lake belongs to the most remarkable water reservoirs of the Baltic countries; originally an inlet, as most of the other lakes of the Baltic, it is now separated from the sea by a narrow strip of maratime deposits. Hills of about 100 ft. in height protect it against all winds in such a manner that Napoleon I. designated it for a winter harbor for his Baltic fleet, when, by the catastrophe of 1813, the whole project fell into oblivion. Moreover, this natural harbor is situated in the midst of one of the most populous, prosperous, and best-cultivated districts; it is surrounded by a circle of charming villages, and only awaits the completion of the projected canal to become an excellent seaport. The length of the section from this lake to Gluckstadt is 48 miles; adding thereto the distances through the lake and from Lubeck to the Baltic, we have a total length of 53 miles, or over half the length of the Suez Canal. The cost of the execution of this work, including the construction of harbors at Gluckstadt and Lubeck, has been estimated at $23,720,930 in gold.

Should a work of this kind be executed, a yearly passage of from twenty to thirty thousand vessels through the canal might safely be predicted. Such a strait would open to the ocean the immense territory of Russia; and besides this, the Prussian coast, which is over half the length of that of France, would be made directly accesible to the open sea.

Taking all in all, the cutting of the isthmus of Holstein may safely be contrasted with that of Suez. In shortening an old way of traffic, it will contribute towards transforming the slow march of civilization in the northern European countries into one worthy of this century of steam.

The traffic returns of the London and North-Western Railway shows an increase of £3,481. In the case of the Midland the increase is £4,456. The Lancashire and Yorkshire exhibits an increase of £282. The Manchester and Sheffield return presents an increase of £382. The Caledonian return shows an increase of £344. The Great Eastern Railway exhibits a decrease of £410. The London and South-Western shows a decrease of £1,420. The Great Western returns a decrease of £590. The London, Chatham, and Dover Railway shows an increase of £455. The Metropolitan extension of the London, Chatham, and Dover, presents an increase of £324. The Great Northern Railway return shows a decrease of £733.

The Darien Canal project is reviving. The United States steamer Nipsic, attached to the South Atlantic squadron, is under orders to proceed to the Isthmus of Darien to make surveys and explorations, with a view to determine the best location for an inter-oceanic canal. A similar survey on the Pacific shore of the Isthmus will be made at a future day.

INDIAN STATISTICS.

From "Engineering."

A report, containing a series of statistical maps of the Indian empire, compiled by Mr. F. C. Danvers, has recently been published by order of the House of Commons. The maps, eight in number, indicate the districts and divisions of British India, the native States, the distribution of languages and dialects, the cotton districts, the principal products besides cotton, the division of the salt districts, the progress of irrigation works, and the railways, telegraphs, and light-houses of India. The native languages of India are grouped into four families—the Semitic, the Dravidian, the Thihetan and Indo-Chinese, and the Indo-Germanic. The first forms but an insignificant portion to the others; the second is divided into two branches—the Dravidian, northern and southern, of which the latter is again subdivided into three heads—the first including twelve, the second eight, and the third seven dialects. The Thihetan language, spoken in Bhotan, Nepal, and part of Oudh, is divided into 23 dialects, the Indo-Chinese into 26, and the Indo-Germanic into 11. The different dialects of the latter division are spoken by about 120,000,000, and forms the principal language of India.

The maps and statistics of trade show by inspection the condition of Indian trade from 1834 to 1868. Between the first named date and 1865, the increase was almost continuous, having advanced from £14,000,000 to upwards of £123,000,000, or at the rate of about £3,500,000 a year during that period. From 1855 to 1866 the increase of trade was most strongly marked, the advance having been from £35,000,000 to £123,000,000, being an average of £8,000,000 a year. In 1866-68 a marked falling off characterized Indian business in common with almost every national trade, the total receipts having fallen as low as £96,000,000. India is now purchasing annually £20,000,000 worth of English fabrics, and exporting to the amount of £8,000,000 in general merchandise, besides about 1,500,000 bales of cotton, 8,000,000 lbs. of tea, 37,000,000 lbs. of coffee, while the value of her indigo and silk exports is £2,000,000 and £1,500,000 per annum.

Nearly £3,000,000 annually are collected from 129,000,000 of people, by means of the salt tax, and in order to assist the realization of the duty, lines have been established at which an import duty is levied on all salt crossing them. These lines, exclusive of the Indus, Mooltan, and Berar districts, have a length of 1817 miles, which are guarded by 10,832 officers and men. It is subdivided into 10 districts, and includes an area of some 502,000 sqr. miles. The amount of salt consumed by the 129,000,000 of inhabitants subjected to the tax in 1867-68 is estimated at 13,830,000 maunds, which was obtained as follows:

	Maunds.
From the Punjab Salt Mines	1,200,000
Crossing the Customs Lines	3,730,000
From the South-East Frontier	7,900,000
Smuggled Salt	1,000,000

The average consumption per head amounted to some 3½ lbs., and the duty from 1½ to 3¼ rupees per maund.

The seventh and eighth maps of Mr. Danvers's report contain, in conjunction with their subject-matter, much interesting information as to the condition and progress of public works in India. The construction of roads occupied but little of the attention of the East India Company in early times. And the organization employed for the carrying out of these works, the necessity of which was freely acknowledged, proved so defective that in 1831 the Madras Presidency abandoned all attempts at maintaining such roads as were in existence, and issued instructions that the superintendents of districts should do all that lay in their power, but without any grants from Government. In 1836 the Grand Trunk Road between Calcutta and Peshawur, 1,423 miles in length, was commenced, and has been thoroughly maintained; but it was only in 1855 that the absolute necessity of constructing an efficient system of road communication was impressed seriously on the Bengal Government. In 1860-61 the formation of a system of imperial roads began in earnest, and it was intended that each district should be provided with at least one main line, passing through the principal towns or stations of the districts, and in connection with the adjacent dis-

trict's arterial way. In addition to these, the necessary branches were to be made. At this time there were in existence some 1,994 miles of main road, and 1,145 miles of branches.

In the Punjab, road construction had advanced more successfully. Immediately after its annexation an annual grant of 5 lacs of rupees was sanctioned for public works, and the greater proportion of this sum was at first devoted to the formation of a military road between Lahore and Peshawur. In 1854 there had been 3,600 miles formed, and by the end of 1856 a length of 8,749 miles had been opened.

After the Madras Presidency had partially recovered from the difficulties which had defeated their efforts to establish an efficient system of roads, new efforts were made, and between 1837 and 1843 several new lines were opened, and the old ones improved; but it was not until 1848 that the work progressed rapidly. In the ten years, 1848-58, 4,009¼ miles were opened, of which 188 miles were first-class roads, and the remainder roads of the second and third class.

River navigation also occupied much of the attention of the Government, and it was probably owing to the natural facilities afforded by the network of streams, that road construction was neglected. The Ganges, in the North-west Provinces, the Brahmapootra, in Assam, the Indus, in the Punjab and Sindh, and the Madras rivers were all largely available, and afforded means of access from the seaboard to the interior. The improvement of the navigation, the dredging of the streams, and the construction of embankments, have, therefore, given much occupation; in Bengal 2,594 miles of embankment have been made, which protect the surrounding country from inundations.

The ancient native irrigation canals, of which many existed, began to be restored in 1817, and in 1822 the Doab Canal works, which have been so severely criticised of late, were commenced. The Ganges canal, the first new work of the kind attempted, was begun on the 16th April, 1842. The canal system was inaugurated in Madras five years later, and since then large sums have been annually granted, increasing with each year, until the last grant amounted to £1,779,397.

In the early history of English occupation in India little attention was paid to the construction and improvement of harbors. There are but few good harbors around the coast, although on the Madras seaboard alone, cargo is received and discharged at no less than 144 points; the improvement of the Mutlah commenced in 1855 as an auxiliary to Calcutta; in Madras large sums have also been expended in improving several ports, and in Bombay, Karwar and Kurrachee have become situations of importance. The latter works were commenced in 1860, but were stopped for some years, being recommenced in 1868, and are now in progress.

Fifty-four light-houses protect the navigation around the Indian and Burmese coasts; some of them were built as early as 1817, but for the most part they have been constructed within the past thirty years.

Such is a *résumé* of the principal facts contained in Mr. Danvers's official paper, which possesses, to recommend it, besides the length and extent of its statistical information, a graphic delineation of the most interesting topics connected with Indian trade, and improvements in the finely executed series of maps which are comprised in the report.

The Russian Government has granted a concession of 30 years to M. Titgen, Councillor of State to the King of Denmark, M. Erickson, a merchant, and M. Pallisen, consul-general for that country at St. Petersburg, for the establishment of submarine telegraphic lines between Asiatic Russia and Osaka, Yokohama, or Nangasaki, in Japan; and Shanghai, Foudjaon, and Hong-Kong, in China. The company thus formed will ask for the authorization of the Chinese and Japanese Governments, and the Russian executive will lend its good offices in the matter. The concessionaires bind themselves to attach this system of telegraphy to a station and telegraphic line of the State in Russia in Asia.

The Greenwhich Hospital Pension of £65 a year vacant by the death of Mr. T. Bullions, chief engineer, on the 8th inst., has been awarded to Mr. Thomas Brown, inspector of machinery, from that date.

THE APPLICATION OF PHOTOGRAPHY TO SURVEYING PURPOSES.

By CAPTAIN STOTHERD, R. E.

From "The Building News."

The attention of photographers has recently been much turned to the utilization of this very useful branch of art, and many excellent applications have been discovered, the practical results of which may be seen every day. There is, for example, the very beautiful process of the reduction of plans by photography from a large to any given smaller scale, by which the saving of time and labor is enormous, and the accuracy obtained far greater than that which would result from any mechanical mode of reduction. Again, there is the photo-lithographic process, and others besides, which it is unnecessary here to enumerate. Among the most recent applications of photography is the attempt to bring it to bear practically on field surveying, and by it to obtain data from which an actual survey may be plotted as from an ordinary field-book. This has been done in Austria with considerable success; and again in the Paris Exhibition of 1867, Mons. Auguste Chevallier, No. 1 Rue de Conde, Paris, exhibited a very neat and clever instrument, designed with the same object in view.

The rapidity and accuracy with which photography, as applied in this way, is capable of recording, in true relative position, the different objects composing any view falling within the focus of the lens of an instrument, render it highly probable that at no very distant day it may come into general use for military purposes, and that instruments (if not like that of Mons. Chevallier, on somewhat similar principles) may form a part of the equipment of every army which takes the field; a description of it may therefore be interesting.

It consists of a stationary horizontal plate or table, supported on a tripod-stand, over which a movable plate is arranged to revolve, with a uniform motion, by the action of clock-work. This upper movable plate is provided with a prism or mirror, by which the image of an object in front of it is projected upon the stationary horizontal plate. By means of a simple arrangement fixed at the lower part of the tube, carrying the prism, the light can be effectually excluded at any point during the period of its rotation. As the upper plate revolves, the image of each object, as it passes in front of the prism, is projected on the lower or horizontal plate in true relative position; and if a sensitized glass be introduced in connection with this stationary horizontal plate, a panoramic view of all objects presented during a single revolution of the upper one is photographed thereon, each object being in truly mathematical relative position with all others in the same panoramic view, with reference to the central point on which the instrument revolves.

This central point at which the instrument is placed corresponds exactly with a trigonometrical station at which, in the ordinary operation of surveying, a round of angles is taken by a theodolite; and the panoramic view corresponds to a round of observations, which are, however, in Mons. Chevallier's arrangement, recorded in the form of a picture, round the circumference of a circle, described with the trigonometrical station as its centre, whereas in the ordinary mode of procedure they are represented by a series of bearings with reference to a given meridian, and recorded in the form of angles therefrom.

The opening in the upper plate through which the image is projected upon the sensitized glass, is in the form of a slit, about one-third of an inch wide in the outer circumference, and gradually tapering towards the inner circle, bounding the exposed surface, its sides being in the direction of the radii drawn from the centre of revolution of the instrument. A simple arrangement covers this slit and excludes the image till the moment for exposure arrives, when it is opened by turning a mill-headed screw. The time of exposure is regulated by the rate of the clock-work, each object being presented in succession on the sensitized glass during the interval of time taken by the slit or opening to pass over the arc of the circle corresponding to it.

The image can be cut off at any point required during the revolution of the instrument by simply turning the mill-head-

ed screw already mentioned so as to cover the opening; and thus any portion of the panorama may be photographed at will, without completing the whole revolution. The mean of focusing is attached to the upright portion, and a small telescope in connection therewith gives the power of regulating it, so that a sharply defined image may be obtained. The image produced on the glass is a negative, which may itself be used in plotting the different points of the panorama on the plan, precisely in the same way that a round of angles is plotted by means of a circular protractor; when there is time, however, a print from this negative affords a more convenient medium for this purpose. In making a survey with this instrument, a base is measured, and panoramic views from its extremities, and from other points required, are taken; and the positions of the most defined objects being laid down by plotting on the plan, by means of the pictures obtained, the remaining detail is readily inserted by minor measurements, productions, and intersections. Mons. Jouart, Lieutenant of Artillery of the Imperial Guard, has published a very interesting and detailed account of this apparatus and of its use, from his own practical experience, as a surveying instrument combining, as it does, considerable accuracy with rapidity in obtaining the necessary data for plotting. The record being self-acting, no error can arise from a mistaken entry of a bearing. If a series of views were taken from prominent points, a system of triangulation might be rapidly carried over any district of country, and on this triangulation the detail could be very readily built.

It would be very desirable to test this instrument practically, in order to obtain some idea of its working powers. As regards its disadvantages, which appear to be the necessity of carrying about a dark tent and certain photographic apparatus, and the employment of trained photographers, I would observe that, as a photographic equipment will probably form an appendage of every army that takes the field in modern warfare, the first objection is scarcely worth considering, provided the instrument itself can be made in a sufficiently portable form for transport. As regards the necessity for providing skilled photographers to work it, men with comparatively little previous knowledge will answer the purpose, if first-rate hands cannot be obtained, because the pictures to be produced are not required to be kept as works of art, but are simply to be used for plotting purposes, for which such great perfection is not necessary. Mons. Jouart states that some of the negatives used by him in his surveys were taken by men who had had only three or four days' practice in photography.

In addition to the mode of working this instrument already described, it may be used without clock-work, by simply arranging it to remain stationary at certain given points round the circumference of the circle of the panoramic view to be taken, the distance between the stationary points at which the apparatus is fixed for each view being regulated by the space on the sensitized glass on which the image of the view to be taken will be cast in proper focus. The effect of this process is to produce a series of views forming a panorama, and, in point of fact, giving a very similar result for working purposes to that obtained with the clock-work, the only difference being that in the one case a series of views is produced, whereas in the other the result is one continuous picture, extending without a break completely round the circle.

When no clock-work is used, the arrangements for exposing the sensitized glass are somewhat different from those required with the continuous action as already described. a broader space being exposed for a certain definite interval of time, and then the apparatus passed on to the next space, which is in its turn exposed, and so on till a complete circle, or portion of a circle, has been photographed. The instrument exhibited in Paris at the International Exhibition excited a great deal of interest; it is a comparatively new idea, and it is to be hoped that it will prove as useful as its inventor anticipates.

CHICAGO is going into the iron manufacture on a large scale, and with Lake Superior ores. A number of capitalists there have formed a company, and contemplate the erection of a large mill at Joliet. Wrought-iron gas and water pipes will form one feature in the production of the establishment.

IMPROVED PISTON FOR STEAM AND OTHER ENGINES.

By MR. T. H. MARTIN.

From "The Mechanic's Magazine."

At the annual meeting of the Miners' Association of Cornwall and Devon, recently held at the Polytechnic Hall, Falmouth, Pendarvis Vivian, Esq., M. P., in the chair, the following important and interesting paper, by Mr. T. H. Martin, of the Morfa Copper Mills, Swansea, was read, it being selected from amongst several other papers which had been sent in for discussion:—

The piston being the medium by which the power of the steam is exerted and transmitted through the rod to the work to be performed, it naturally forms one of the most important parts of the steam engine; consequently the duty of the engine, in a great measure, depends on the efficiency of its work. Pistons are of various constructions, but all may be classified under two heads, viz., those for single-acting and double-acting engines. In single-acting the steam is admitted on one side of the piston only, the reverse side being generally hollowed out; whilst in double-acting engines the steam is admitted on both sides alternately. It is not material in the construction of a piston whether the engine is condensing or non-condensing.

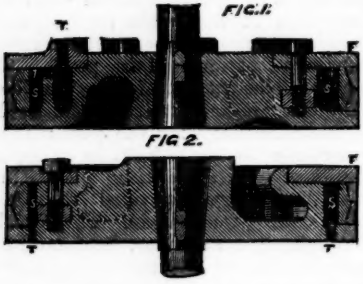
I propose to refer to each class of piston in the following order:—First, to those for single-acting pumping engines; second, to those for double-acting engines. I purpose briefly describing the form, and to point out the disadvantages attached to pistons that are generally applied to single-acting engines. They are variously constructed, as before remarked, particularly those parts—*i.e.*, the rings—which are brought into rubbing contact with the cylinder. These are generally made parallel or bevelled; they are invariably packed behind with greased gasket, india-rubber, lead, or with patent packing, for the purpose of pressing them against the cylinder, or to make them steam-tight. Goodfellow's bevelled rings, fitting between flanges of piston, with a narrow wedge-like ring behind, are sometimes used; also Ramsbottom's small square rings, which are fitted into the periphery of the piston. Some use Stephenson's method, consisting of rings with steel springs, and bolts for tightening; others adopt segments with wedges. These and various other methods have been applied from time to time for producing continuous steam-tight pistons, but hitherto without success. Having briefly described a few of the varieties of pistons in use, which may be classified under two heads, viz., packed and spring, I will now point out the disadvantages attached to each. Packed pistons are those which are packed with gasket, etc. They continue steam-tight for a very short period only, and even when in that state produce enormous friction, so much so that the engine is deprived of much of its power. The friction is also the same in the "outdoor" as in the "indoor" part of the stroke; this is unnecessary, for the piston is not required to be steam-tight in going the "outdoor" part. Spring pistons are those which are provided with steel springs, bolts, wedges, etc. They quickly (through wear and tear, heat, etc.) lose their elasticity, producing results precisely the same as in packed pistons. The steam in escaping is not only a loss of power in itself, but on its escape to the other side of the piston, which is open to the condenser, partially destroys the vacuum.

The following may be taken as showing the principal disadvantages attached to pistons now in use: First, when steam-tight, increased friction from being newly packed, and unnecessary friction when going the outdoor part of the stroke. Second, steam, in escaping, is a loss of power in itself. Third, in its escape it considerably decreases the vacuum, which is also a loss of power; and, last, the great expense of labor and materials, etc., in packing, with the necessary delays occasioned therefrom.

It is an admitted fact by all engineers who have at all considered the matter that the Cornish pumping or single-acting engine is capable of developing a far greater amount of duty than any other class of engine when under similar conditions; and it is with the view of an increased development of power in this type of engine that I suggest the introduction of

steam-tightening pistons. The good results obtained from trials made, prove that the great advantages they possess result from the principle on which they are constructed, and I feel assured that a trial only is necessary to convince any one of their superiority over the present method. Steam-tightening has been adopted for many years past for locomotive and other small engines, but from the imperfect method of admitting the steam, and defective construction of the piston and rings, they have in most cases been abandoned.

The forms of piston I propose for single-acting pumping engines are in Figs. 1 and 2 in accompanying engraving. Fig. 1 is

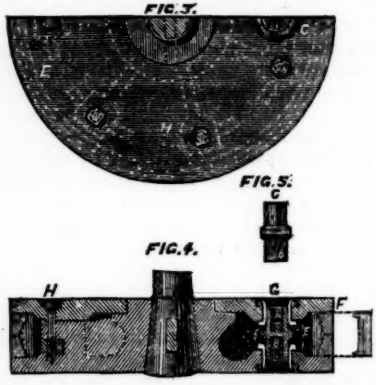


for a piston where steam is admitted on top, as for the ordinary single-acting pumping engine. Fig. 2 is for a piston where steam is admitted under, for single-acting of the inverted type.

The piston may be described thus:—The form of the body does not vary much from those now in use, and may be fitted to the rod in precisely the same manner. The difference is in the rings, which are three in number, and are well fitted to each other, ground and scraped to flange of piston, and to lugg ring. To allow for the wear of the outer rings, the inner one is made a little larger in diameter, and a piece is cut out of its circumference to make it fit at the back of outside rings; a spaces S (a little larger than that which is generally allowed for packing in packed pistons) is provided for steam, which is admitted through holes T, arranged as in Figs. 1 and 2. By this arrangement, when steaming, a continual pressure, equal to the working pressure, acts against the inner surfaces of the inside ring F, which presses the others against the cylinder in such a manner as to effectually prevent any escape of steam from one side of the piston to the other.

The advantages gained by the above piston over that of the ordinary construction are:—Economy in fuel; increased power from less friction (for when in equilibrium the latter would be very trifling); the saving of steam that would otherwise escape, thereby increasing the vacuum; effecting a great saving in labor, and materials for packing, and also in preventing delays. Seventy-five per cent. of the old pistons could be easily converted into steam-tightening on this principle, and at a very trifling expense.

Referring, secondly, to pistons for double-acting engines. Those generally used are, as before described, for single-acting engines, and any advantages with



regard to increase of power and economy in fuel which may be derived from steam-tightening in that type of engine would be double when applied to engines of this class. The method for admitting steam behind the rings, as shown in Figs. 1 and 2, would necessitate the piston being provided with two sets of steam-tightening rings, one for each side of the piston, also with two lugg rings, with bolts, nuts, etc., and then only one set of rings would be steam-tightening at the same time, the other being drawn inward by vacuum, when from one side or the other a continuous rattling of the rings would ensue, thus producing the following objections for steam-tightening the pistons of double engines, on the principle of those for single-acting:—First, the piston would be required more than twice the depth it need be. Second, the continuous noise

consequent from rings being acted on alternately by steam and vacuum.

To obviate these objections, and to use only one set of rings, I have designed a piston as seen at Fig. 3 in the accompanying engraving, and for which letters patent have been granted.

These figures represent a half plan and a vertical section of the piston of a 36-inch horizontal condensing engine, which has been working for the last six months night and day (Sundays excepted), effecting a saving in fuel quite 15 per cent., with 10 per cent. additional power. The cylinder was opened a few days since merely for inspection of piston, and, to my great satisfaction, scarcely the slightest amount of wear was discovered, either in valve or rings, it being steam-tight in all parts of the stroke. The vacuum has been improving from its commencement, and may now be considered as almost perfect; this has arisen no doubt from the rings and cylinder becoming better fitted to each other.

The invention consists in the introduction of a valve, C, in the body of the piston having chambers, B, formed in its interior at each end. Around the sides or walls of these chambers, and communicating with the interior of the piston, are any convenient number of ports or openings, D. These, as the valve is forced to and fro alternately, communicate with the interior of the piston, E, allowing the steam to press or tighten the rings, F, against the the sides of the cylinder. H are bolts for securing the lugg ring. To prevent "blowing through" while the valve is in motion, the port-holes are so constructed that one side will have closed before the opposite one opens. The valve or valves may be made either single or double, and placed opposite to each other, or otherwise, as may be found most convenient.

The advantages gained by this invention comprise the following: the economizing the entire cost of the springs, bolts, and nuts in the construction of ordinary spring pistons, aud with the common packing with yarn, vulcanized india-rubber, and lead. There will be a great saving also in labor and fuel, prevention of delays in opening cylinders, etc., and the loss of power to the engine on account of the springs, rings, and packing losing their elasticity.

After reading the paper, Mr. Pearce remarked that he could bear testimony to the efficiency of the new description of pistons, having seen them in engines at Swansea.

THE SPIRAL PUMP.

From "Engineering."

It is with much pleasure we notice the great improvements Mr. Airy has just made in a hydraulic machine of a very remarkable character, hitherto but little understood. Although the spiral pump—as Mr. Airy states at the outset of his valuable little work on the subject now under review—"was invented more than a century ago by Andreas Wirz, the tin worker of Zurich, and was afterwards made the subject of theoretical investigation by Bernoulli and Eylelwein, and in spite of the unqualified approbation bestowed upon it by all who have studied its action, the machine has been practically ignored, and as a consequence it has not received that attention to mechanical details which so greatly tends to the improvement of a machine; indeed it does not appear that more than four working specimens have ever been constructed." The reason why so little progress has hitherto been made in the improvement of the machine is, in the opinion of the author, due to the rudeness of its construction, and we venture to add—what Mr. Airy's modesty would not allow him to do—to the very complicated nature of the theoretical investigation involved in the action of fluids moving through spiral channels, a subject Mr. Airy has evidently thoroughly investigated and made himself master of. It is gratifying, indeed, to observe that the author in dealing with this subject is able to bring to bear upon it, not only the attainments of a high order of mathematical knowledge, which, as the son of the Astronomer Royal, we might perhaps naturally look for, but that thorough practical knowledge of mechanics, which we know Mr. Airy has acquired—in the only way it can be properly acquired—by going

through the usual apprenticeship of the workshops.

In addition to the causes just referred to, as operating against the more general use of the spiral pump, may be added the great irregularity which has hitherto attended its working, arising from the discharge of both air and water through the vertical pipe, and the difficulty of making good the water-tight joint. Both these difficulties have, it will be seen, been successfully overcome by Mr. Airy; in the first place by the addition of a separate chamber to receive the alternate discharges of air and water through the spiral coil; and secondly, by the simple and ingenious form of leather joint he has adopted. By these means, and by carefully investigating the theory of the principles involved in its action, in which he has been materially assisted in his preliminary investigations by the use of a model with glass coils, the author has converted what has hitherto been but of little practical utility, into a highly effective hydraulic machine, capable of raising water to great elevations; and, under many circumstances, where there is an abundance of water supply even of a very low fall, it is easy to see that it is capable of most useful and economical application.

The following extracts and illustrations will enable our readers readily to understand the principle upon which these improved spiral pumps are worked; but for a great deal of other very interesting and valuable information in regard to it, we would refer them to the work itself: *

The spiral pump is constructed as follows: A metal pipe is coiled round a cylindrical or conical drum, which is placed with its axis horizontal; this drum is carried by means of two axial pivots—one, a solid gudgeon, running in fixed blocks, and carrying on its end a crank, by means of which the drum can be turned; the other, a strong pipe leading into the curved end of an upright pipe, in which it turns by means of a water-tight joint; one end of the metal pipe on the drum is left open, while the other end is led into the side of the horizontal pipe gudgeon above described, and soldered to it at the joint.

If the above machine be erected at the surface of a reservoir of water, and so placed that the drum is more or less immersed; then, as the drum is turned, the open end of the pipe that is coiled on the drum takes in a portion of air and a portion of water at every revolution; and when the drum has been turned as many times as there are coils of the pipe upon it, then the pipe on the drum is full of these fluids in regular order, the water in each coil lying at the bottom of the coil, and the air at the top (the quantity of each depending upon the depth of immersion of the drum). If now the drum be still turned, the water and air in the last coil are discharged into the horizontal pipe gudgeon of the machine, and by it into the vertical pipe; and at every additional turn of the drum an additional discharge of air and water takes place into

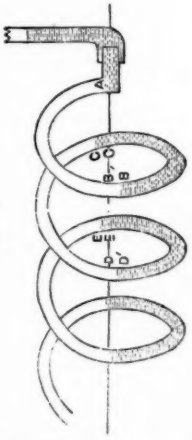


Fig. 1.

the vertical pipe; the air at once rises to the surface and escapes, but the water remains in the vertical pipe, and establishes a column of fluid, which is supported as follows:

Suppose that all the coils of the machine have been filled as above described, and that at the next turn of the drum, water will be discharged into the vertical pipe; also suppose that the drum is cylindrical, and is immersed to half its depth in the reservoir, so that the quantities of air and water in each coil are equal, then the position of the fluids will be as shown in Fig. 1; the drum has received the additional turn, and a charge of water has been delivered into the vertical pipe, in consequence of which the water has risen in

* The Spiral Pump, applied as a Force Pump, etc., by W. Airy, B. A., etc. Willis, Southeran & Co., London.

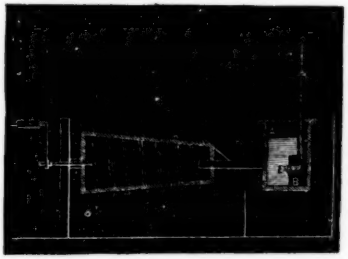
that pipe, and a pressure column is established. The pressure of this column acting upon the surface of the air at A, and transmitting its pressure by means of the air in A B to the surface of the water at B, tilts up the column of water, B C, so as to make it assume the position B′ C′, and thus establishes a small column of water (equal to the difference of level of B′ and C′) tending to balance the water column in the vertical pipe. At the same time the water column, B′ C′, transmits the pressure (lessened, however, by the portion which it carries itself) by means of the air in C′ D to the water surface in the next coil at D, and the water column in this coil in like manner is tilted up into the position D′ E′, and supports a portion of the column in the vertical pipe; and the same is repeated in all the coils on the drum. These operations must not, however, be understood to follow one another in sequence, but all take place simultaneously; the water column in every coil is tilted up a little, that nearest to the vertical pipe being tilted most, and that nearest to the in-take mouth least; and the sum of the columns of support thus gained in the coils of the pipe is equal to the column in the vertical pipe; and thus equilibrium is maintained.

Let now the drum be further turned. Then more water is discharged into the vertical pipe, and a higher column has to be supported; and, as above described, each of the water columns in the coils will be further tilted up, the coil nearest the vertical pipe taking the greatest share of this additional tilting, and the coil nearest to the in-take mouth the least. Since, then, the water column in the coil nearest to the vertical pipe, receives always the largest share of the work of support, it is clear that the upper surface of this column will always stand higher than that of any other of the columns; and in the progress of turning it will at last arrive at the top of its coil.

If, now, the drum be further turned, the water in the last coil being incapable of doing more towards the work of support, will simply overflow into the coil next behind it, and the columns in the succeeding coils will arrange themselves (as above described), to support the additional column in the vertical pipe. In due course of time the upper surface of the water column in the last coil but one will arrive at the top of the coil; and then this column also is performing its maximum duty, and, on the machine being further turned, overflows into the coil behind it. In this way the columns in all the coils are in succession brought to their position of maximum duty, the column in the vertical pipe constantly mounting higher and higher; and finally, when the columns in all the coils are working at their maximum duty, the machine is lifting to the greatest height which it can accomplish. If, now, the drum be turned the water is delivered backwards by the above-mentioned system of overflow throughout the coils just as fast as it is discharged into the vertical pipe, and no increment of height is attained. * * *

Thus far it has been assumed that the air and water are both discharged immediately into the vertical pipe; and it is in this way that all the working pumps of this kind have been constructed. But there is great inconvenience in allowing air and water to go up the same pipe; the water is discharged irregularly, with noise and shocks, and is charged with air-bubbles. Also there is special inconvenience in making the water-tight joint (the only joint in the whole machine), in the curved end of the vertical pipe. To remedy these evils, the author devised the arrangement exhibited in Fig. 2, by means of which the

Fig. 2.



machine has been made to work with remarkable uniformity and success. A B is an air-tight box, and the pipe-gudgeon, C D, is led into the side of A B by a water-tight joint. This joint is simple and exceedingly tight; it is merely a single thickness of leather, in which a hole is cut somewhat smaller than the pipe; the leather being secured to the outside of the box, as shown in the figure, the end of the pipe is forced through the hole in the leather, which thus is somewhat coned,

and its edge wraps close against the pipe; the pressure of the water acting on the side of this leather cone always tends to secure the joint, which is so tight that it does not let through a drop of water; in this joint the pipe turns with very little friction compared with that of a stuffing-box. E F is the vertical pipe; its lower end is bell-mouthed, to avoid loss of head by contraction of the fluid, and it is stepped on a block at the bottom of the box; at the top is a spout to deliver the water. K is a tap, the object of which will be soon described.

Suppose the tap, K, closed; then, as the drum is turned, air and water are poured into the box; the air, as fast as it enters, ascends to the top of the box, while the water remains below, and is forced up the vertical pipe, as already described.

In this state, the air is of great value, as the upper part of the box then forms an air-chest (as in a fire-engine), and the expansive force of the air, under pressure, insures a regular and even flow of water from the spout at the top of the vertical pipe.

It thus appears that the height to which these machines can force water is determinable simply by the number and size of the coils. The author next proceeds to show how the maximum effect varies in the proportion in which the air and water are alternately taken in at the mouth of the coil, and how the conical form of drum is preferable to the cylindrical in counteracting the prejudicial effects due to the compression of the air in the coils; the singular phenomenon of regurgitation is then noticed and explained. The adaptation of the horn to the intake-mouth, as originally applied by Wirz, the inventor, is then considered by the author, and also the curious effect it has on the arrangement of air and water in the coils.

Before referring to the subject of the general application of this machine, we would say a word in regard to a very ingenious and beautiful application of this principle of the spiral pump, the invention of the author's brother, Mr. H. Airy. In this machine, which is appropriately called a mercury pump, that fluid is substituted for the air, and plays a very important function in its action. Owing to its much greater specific gravity, the mercury column only needs to be $\frac{1}{3}$ of the height of the water column, and the description of the machine very clearly shows how ingeniously, by means of a very small quantity of mercury, which is made to circulate through the coils, a continued stream of water is lifted to a very considerable height. The use of such a machine is of course but of limited application; but for hall and garden fountains, and small fancy jets of perfumed water, etc., no more suitable and effective machine could be desired.

With regard to the advantages of the spiral pump, and the scope for its useful application, we cannot do better than conclude our notice with the well-put observations of the author himself on this subject:

"The advantages of it are numerous and important. Its chief recommendation lies in the simplicity of its action, and the fewness of its parts; there are no sliding valves or other moving pieces liable to expensive repairs, and the one water-tight joint is simple, safe, and easily renewed without skilled labor. The friction may be reduced to a very small amount, for since the drum is always more or less immersed, it will be proper to make the drum hollow and water-tight, so that by proper adjustment of its size, weight, etc., it shall float in the reservoir without bearing at all on the gudgeons. The friction of the water in the pipes is of course unavoidable, but except the velocity of rotation be very great (and this will not be advisable in any case), the friction will not be very considerable.

"The application of the machine would seem chiefly to lie in the lifting of moderate quantities of water to a considerable height, as, for example, the supply of water for domestic purposes from a stream or spring at a considerable distance below the dwellings to be supplied; if there is any fall of water, the machine could be conveniently driven by water-power, and with far greater economy than the hydraulic ram. In such a position its value would be peculiarly felt, as the stoppage of house supply is exceedingly objectionable, and this machine could scarcely anyhow get out of order except at the water-tight joint, which is renewed in a few minutes."

PARIS makes little watches no bigger than a three-cent piece, but the price is $200.

THE ASPHALTE MINES AND WORKS OF PYRIMONT, SAVOY.

From "The Practical Mechanic's Journal."

It is not a little curious how little is commonly known in Great Britain of the asphalte industry of France—one thought so important abroad, and to which we are indebted for whatever asphalte is employed by engineers or architects in our own country. It is equally remarkable how much more largely and universally asphalte is employed on the Continent than it is with us; though there, as here, it competes with artificial—so-called—asphalte, made from coal-tar or its distillation educts, mixed with sand, clay, lime, etc. Chemically, this artificial asphalte may not quite improperly take its title, but its physical properties as a cement or a covering are very different from those of the natural asphalte, and, in certain respects, very inferior.

For mere water-staunch coverings there is no question but that the coal-tar asphalte may, by proper management, be made to answer perfectly; and even as a covering for foot-ways, the experience of many of the *trottoirs* of Paris proves that in skilled and careful hands it can be so laid as to be moderately resistant of strong sun heat, and perfectly so of moisture, and, therefore, of frost.

But even when laid with the utmost skill, it *does* more or less soften with the sun, and the foot leaves its impression if the surface be stood upon without motion for a few seconds. Whilst badly prepared —*i. e.*, with any excess of coal-tar—or with the earthy material badly diffused and incorporated, foot-ways of this artificial asphalte get perfectly sticky, and even half liquid here and there; and "blow-holes" of vapor of some volatile coal-oils open here and there, which afterwards permit the entrance of water, and the next hard frost splits up more or less the adjacent surface. No more valuable or suitable use for this artificial asphalte has been indicated than that so largely found for it in Manchester and Liverpool, *i. e.*, for the cementing together of granite pavement for the streets. It is strange that this employment for it has been so little noticed in London, where we would commend its extension. This great difference between the physical properties as a constructive material of the artificial asphalte, and the natural asphalte of Seyssel or Pyrimont, arises really not so much, if at all, from any differences in the chemical properties of the bituminous matter in each respectively, as to the *state in which* it is combined by mixture with the solid matters in the two cases.

Natural asphalte, more or less like that of Seyssel and Pyrimont, is found in many parts of the world, and in rocks of several different ages or formations, but most usually the rock in which the asphaltic beds are found is calcareous. It is so at Seyssel and Pyrimont; the mines at which places, on the right bank of the Rhone, between Bellegarde (the frontier fortress of France) and Culoz, about an hour and a-half by rail from Geneva, are situated in the Jura limestone.

When the Pyrimont station is reached, close to the grand sweeping current of the united Arve and Rhone, the asphalte works of Pyrimont, the property of Monsieur de Malo, are seen close to the river brink, and a short but steep walk, after crossing the railway, brings us up to the nearest of the many asphalte workings which supply the works. Asphalte is brought to them also from more distant parts of Savoy (still in the Jurassic limestone formation, or in the "Molasse") by barges across and a little down the river, as also to Seyssel, which is a few miles lower down the Rhone upon the same bank, and whose natural mineral riches and manufactured material are identical almost with those of Pyrimont.

The land here slopes rapidly from a sort of rolling and rather inclined mountain table to the south-east of the Jura chain, and from 400 to 600 ft. above the Rhone, down to the river's brink. Climbing about 300 ft. up this steep from the railway, we arrive at the first excavated face of rock, from out of which the asphalte has been extracted, and from which much more remains to be got out. There are horizontal galleries lower down, nearly on the level of the rails, from which asphalte is also obtained, the beds to which these lead being deeper in the rock.

The asphalte-bearing bed (at the upper workings, which are partly open to the

day—a sort of quarry of limited height, with the heavy cap of covering rock not removed) is from 5 to 8 or 10 ft. in thickness, nearly continuous, but very irregular, both in thickness, richness, and form, and, commonly, with very ill-defined boundaries, at the upper or roof side of the seam at least.

The formation of calcareous rock, known as the Jurassic, from the characteristic they afford of the material of the irregular range of mountain stretching along to the north and north-west of the Lake of Geneva, and called *in globo* the Jura—though one long mountain alone, properly bears that name—consists of a vast variety of calcareous materials, from incoherent marls and hard limestones of nearly pure carbonate of lime, to sandy marls and limestones, loose sands with more or less calcareous dust or mud mixed, and liassic limestones of variable hardness, but often very hard, and containing variable proportions of alumina, magnesia, and silica (in a soluble form), which produce in certain beds admirable hydraulic limes. These various qualities of limestone are in many places found mixed up together in a sort of discontinuous stratification, and in the most irregular way and forms; such is very much the case at these Pyrimont mines.

The main mass of the rock exposed is of very variable petrological character, yielding more or less fat or non-hydraulic lime when burnt; but it contains, with a rude, irregular sort of discontinuous continuity, three remarkable beds. The middle one of these, the asphalte, is the subject of our notice; above it *generally* (not always) is found a greenish-gray, soft marl, coherent but friable, and below it a seam, of variable thickness, of dense, close, fawn-colored and gray liassic limestone.

The asphalte bed is of dark hue, varying from perfect blackness but without lustre, to a soft gray or yellowish-brown. It is in fact only a bed of porous limestone, very variably but most thoroughly impregnated naturally with bitumen. This latter can be completely washed out from pulverized specimens by means of sulphuret of carbon as a solvent, and the limestone then appears almost as white and soft and fine as powdered chalk. It is, in fact, almost chemically pure carbonate of lime, containing merely a trace of peroxide of iron, and appears to hold the water found in it merely in mechanical suspension.

The asphalte is worked on the plan called in coal-workings "pillar and stall," and is all taken out by blasting, the consumption of powder being, however, very trifling; when detached, its fracture is coarse, and generally earthy; the surface of fracture straight, or tending slightly to conchoidal. It is soft, so that one piece of asphalte leaves a large umber-brown streak when rubbed against the surface of another. It is neither sticky nor unctuous to the hand, but soils strongly, and exhales the peculiar smell which, once recognized, is not easily forgotten.

Occasionally, however, parts of the seam show glistening master joints and cross ones slimed with gluey asphalte; and now and then, though rarely, cavities are found in the rock more or less full of actual liquid asphalte. These indications occur wholly in the harder portions of the seam and in its lower portions.

We cannot in a notice, necessarily here too brief from want of space, enter upon the highly interesting and curious questions, as to the origin in the play of natural forces which have produced this valuable material, further than to say, that probably in every case the permeation of the porous rock has been produced by natural distillation and sublimation of hydro-carbons pre-existing in other states more or less analogous to coal; the distillation having taken place, sealed up by heavy beds of superincumbent rock from access of air, the temperature being low, but the pressure of the evolved vapors, and that under which condensation has occurred, very great. During one of the most recent eruptions, that of 1862–3, of Vesuvius, which breaks through Apennine limestones—lithologically very much of the character of those of Jura—all the wells about Torre del Greco began to exhale the exact smell of Pyrimont asphalte when heated, and traces of bitumen were observed in films upon the surface of the water sources. There can be little doubt that here asphalte was either being formed from beds of lignite, which are frequent in the limestone of Italy, or that beds of asphalte, already so formed, were being exposed to heat and vaporization.

The asphalte as extracted from the Pyrimont mines is passed down to the works by a double inclined tramway, the

surface contour of which in section is a nearly exact parabola, the empty wagons being taken up by the descent of the full ones. The works for its preparation for market also lie upon a rapid slope, and advantage is taken of this form of the ground, so that the raw asphalte arriving first at the highest level passes down by its own gravity, as it also passes through each process, until, arrived at the bottom, it is ready for shipment on the river; that which is to be sent away by rail being hoisted up again, by the steam power of the works, to the level of rails upon a short direct and steep tramway by means of a wire rope.

The asphalte of commerce occurs in two forms: 1st. The natural asphalte merely reduced to a coarse and uniform powder, about the size of mustard seeds, which is employed for laying floors, footways, streets, etc., mixed or not with dry sand, or with sand and lime.

It is simply heated in cauldrons to about 250 degs. Centigrade, spread out upon the prepared base or foundation, and beaten and consolidated with heavy instruments of cast-iron heated *nearly* to low redness.

Laid in this way the asphalte is *nearly* rain-proof, though not so, to even a small head of water, and is, when hardened, solid, firm, and coherent. The preparation at the outset, or first operation, is the same for this and for the second sort of asphalte, viz., that which is sold all over the world in round-shaped flat cakes or blocks, weighing about 100 lbs. each, and which, when to be used, are quite melted up into a thick liquid like pitch, and in that state ladled out upon the prepared floor to the desired thickness, with or without admixture with sand, lime, or other pulverulent matter. In this state the consolidated asphalte is compact, water-tight under any head of water, harder than the former, rather more brittle in extreme cold, and rather softer in great sun heat.

The raw asphalte is powdered in mills driven by power, which requires to be large from the toughness of the material. The mills are of various sorts; edge stones, like those of common corn-mills, and heavy cast-iron sharp-toothed conical hopper mills, like our bark mills, or gigantic coffee-mills. Carr's patent centrifugal quartz-crushing, or rather breaking, machine, is now in process of erection, and about to be tried for smashing up the larger lumps. The writer, however, does not anticipate any great success from its application to this rather tough material. No "stone-breaking machines" of the class now in such frequent use for crushing road metals and ores, etc., are as yet employed.

A large train of lifting machinery, mainly consisting of revolving screens, succeeds the crushing machinery, and are chiefly employed for the asphalte to be laid dry as it is called, *i. e.*, spread in powder. Separated into different finenesses and qualities, this powder is packed in casks for export.

For the manufacture of the fused cakes but little previous crushing is required. The natural asphalte cannot be melted as it comes from the rock, by any amount of heat applied with ordinary rapidity, without the destruction of a considerable portion of it. Indeed, heated *dry* it takes fire after evolving much gray-blue smoke of asphaltic vapor, long before it shows any signs of melting or even of softening.

The process, therefore, by which it is rendered a viscid liquid, is a double one, dependent partly on solution, partly on fusion, or perhaps it would be more correct to say that it is simply fusion aided by heat. The solvent employed is not the product of the Seyssel or Pyrimont mines, and is brought to the works from so distant a point as from near Autun, in France. At Autun there is a vast manufacture of shale or schist oils, *i.e.* of various more or less volatile hydro-carbons, applied to several purposes in the arts as well as to illumination, procured by distillation from bituminous *shales* or *schists*, after the methods first successfully employed, if not first pointed out, by M. Selligues. In the refinement by fractional distillations of these crude shale oils, there remains a large amount of a peculiar viscid, but at any ordinary temperature more or less liquid, dark-colored, and peculiar-smelling *shale or schist tar*.

This is the solvent employed for the Pyrimont asphalte. It is brought in casks (iron tank wagons would be much better) by rail, and at once started into a huge masonry tank for storage at the upper part of the works; this is covered from rain.

Into deep rectangular boilers, each

about 3 metres long, 1 or 1.2 metres wide, and 2 deep, is put a certain quantity of this schist tar; a gentle heat is applied direct by coal fire to the whole range of these boilers, and when the tar boils slowly, an equal volume of the raw asphalte, in powder or small lumps (just as it comes), is added; the heat is maintained for 12 hours, and at the end of that time the whole of the asphalte is found to have been dissolved and combined with the tar.

From the heterogeneous nature of the natural asphalte, however, as already described, many nodules, or portions of finer divided matter, do not dissolve at all, but remain incoherent in the bottom. This is little more than mere limestone, though penetrated, or, at least, colored by asphalte, and externally black and covered with tar.

The boilers have perforated false bottoms, and cocks and mains by which, at this stage, the thick liquid matter is racked off from the undissolved residue, and is passed directly down below, without cooling, into another very large rectangular cauldron, in which the produce of the whole range above gets united. This is kept warm by coal fire heat. Out of this the now formed asphalte is laded by hand, by men naked to the waist, and put into buckets which hold just the right quantity. These are carried away by other gangs of equally stripped men, who fill out of these buckets the wrought-iron moulds, ranged upon the floor, in which the cakes of asphalte set hard, and removed from which they are ready for market.

The liquid asphalte is not to the eye even, a homogeneous fluid; it looks, though at a low temperature in comparison, almost exactly like liquid trachytic, or certain basic sorts of lavas, which consist of a glossy slag, filled full of less fusible crystals, all flowing along together accordingly; except that it is intensely black and shining, this liquid asphalte looks very like very coarse oatmeal porridge, in which the grains of large meal are still quite discernible.

Each mould consists of a ring in two segments, each formed of flat bar-iron about 6 ins. wide by $\frac{3}{4}$ in. thickness. To one of these inside is riveted a cast-iron plate with the name of the maker (Malo, Pyrimont) in relief upon it, so that the cake, when hard, shows this trade-mark in *intaglio*. The floor is of cast-iron plates, kept smeared with white clay and water, with which also the moulds are constantly kept coated. They simply lie upon the floor, and the two segments are heavy enough not to separate when filled. The buckets are, though kept hot, dipped into water each run, so that the asphalte parts cleanly from them. The filling and emptying goes on rapidly, so that eight men do the entire work of moulding of the concern, the machinery of which occupies an engine of 35-horse nominal power.

The men are powerful, but the labor is obviously severe, and not free from occasional danger of a burn. Besides the asphalte of his own mines, Monsieur de Malo now works up a large quantity of bitumen or asphalte from the Pitch Lake of Trinidad, which is at present imported largely into Marseilles.

It is to be regretted that our own manufacturers and organic chemists have as yet all but ignored that exhaustless source of bitumens of several sorts; the more so as one of the most recent discoveries announced in the limitless field of organic chemistry is the production of *artificial alizarine* (a substitute for madder), from *anthracene* (paranaptaline), obtained by acting upon these very asphaltes of the Jura; and that the Pitch Lake of Trinidad may yet be one of the greatest sources of coloring matter for the whole world, needs no stretch of imagination to foresee. As yet, neither at Pyrimont nor at Seyssel have any attempts been made to obtain any other products from the natural asphalte than we have above described; perhaps a not unnatural consequence of a well-paying trade, which nature herself has made almost a monoply.

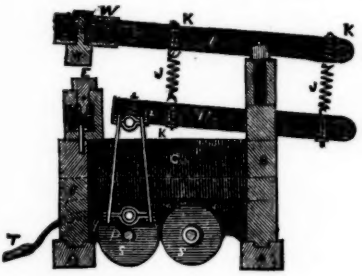
KOURIE CEMENT.—A new gum has been introduced to the trade, obtained from trees in New Zealand; it is called "kourie," and has found to be a most excellent, strong, and water-proof cement for calking tanks and cementing pieces of glass, stone, or wood together. Before using, it is fused or mixed with one-third part of its weight of castor-oil.

DR. TSCHUDI in his "Travels in Peru," says of Lima, that, at an average, 45 shocks of earthquake may be counted on in the year.

OPERATING TILT HAMMERS.

From "The Mechanics' Magazine."

Mr. T. T. Prosser, of Chicago, has invented the method of communicating power to tilt hammers shown in the accompanying cut. His invention also relates to the arrangement for hanging, operating, and controlling the hammer, and the changing of the hammer dies both in the hammer head and in the anvil. The invention has recently been patented in England. Our engraving shows a vertical longitudinal section of the apparatus.



A A are two sills which form the base of the machine frame; B B are two posts inserted in the sills to receive the balance of the timbers composing the frame. Bolted on each side of the posts B are two longitudinal pieces C forming the side timbers. The rear post is longer than the front one, so as to receive the cap or cross piece D on its upper end. By thus arranging the frame all parts are in position to receive the working parts of the machine, and form a durable and perfect arrrangement. On the upper end of the front post is the anvil block F, containing the die E, which is made adjustable and is easily removed. Upon the upper and lower side of each end of the cross piece D are fulcrum or pivot boxes G to receive the pivots H passing through the vibrating arms I and I^1, which are connected together and held in position by the springs J and bolts K. The arms $I I^1$ are in pairs, and the lower pair of arms is shorter than the upper pair; and the arms are in each pair much further apart at the rear end than at the other or front end; the rear ends of each pair are not connected, whilst the front ends are. The lower pair of arms is connected at the front end by a pin *l* and the bolts *m*. In the middle of the pin *l* is a box *n*, to which are attached the eccentric rods that vibrate the arms I^1 and I by means of the eccentric O on the shaft P, which is connected to the short arm of the levers *q*, which are pivoted at R, and, as the eccentric is driven by the friction wheels S, it will be evident that as the foot is placed on the footboard T the shaft P will vibrate and bring the wheels in contact with those driven by the belt *u*. As the pressure of the foot causes an increase of friction, the vibrations correspond therewith. As the hammer is moved up and down by these vibrations, the faster the vibrations are the harder the hammer will strike, and the slower they are the slighter blow the hammer will strike. As these motions are under the control of the operator by means of the footboard T and lever *q*, the machine can be made to strike just such a blow as the operator may desire.

The upper pair of arms are longer than the lower arms, and their front ends are permanently attached together by means of two plates *w*, through which the hammer shank passes, and to which it is attached by the nut V on the upper end of the hammer shank. The hammer shank near the hammer W is square, and the hole in the plate on the under side of the arms through which it passes is made to correspond therewith, whilst the hole in the upper plate is round. The object of making the hole and hammer shank square is to keep the hammer from turning. By connecting the lower arms to the upper by means of the springs, the inertia of the hammer when at rest and the recoil when at work are overcome in such a manner as to relieve the machine from those violent shocks incidental to the common tilt hammer and to convert them into useful effect; for as the hammer is thrown up by its momentum to a greater distance than the movement of the eccentric, an increased amount of tension is imparted to the forward springs; and when the hammer descends, the increased tension causes it to descend with increased velocity and additional force, thus being enabled to strike a much quicker and harder blow than can be done by the machines now in

use. As the springs admit of a ready adjustment by means of the bolts and nuts, it can be readily adjusted to a rapid or slow motion as desired, and as the shock consequent upon a vibrating motion caused by a reverse movement is all taken up by the springs, its motions are all easy, and it cannot fail to be durable, the importance of which advantages must be evident to all who are acquainted with the vast amount of labor performed by this class of machines.

HINTS ON HYDRAULIC JOINTS.

From "The Engineer."

Extensive as the present application of hydraulic power undoubtedly is, there is no reason why it should not be much more so if two causes of retardation were removed. The first of these is, that the extreme adaptability of hydraulic pressure to many operations requiring but little power is as yet not understood. For instance, in very many cases a steady and perfectly smooth motion, such as can be regulated to any speed, and also so arranged that the power cannot rise above a certain point, would be invaluable for small manufacturing purposes. Now, if, as is generally the case, a screw, cam, or other ordinary mechanical means be used, the gradation of speed—though simple enough in its first design—offers a difficulty in general when the apparatus is in motion. Further, should any obstruction occur, the power at once begins to accumulate, till in many cases the force becomes so great as to cause the destruction of some part of the apparatus or of the article being operated on. The practically perfect non-elasticity of water gives just the advantages required. A motion of complete uniformity can be obtained; it can, without stopping the operation of the apparatus, be regulated to any desired extent, from *nil* to the most rapid motion originally provided for in the designing of the machine. Should the resistance be increased by any obstructions the machine will simply stop, instead of destroying any part of itself or the material on which it is acting, supposing always that ordinary care and knowledge are exercised in proportioning the work, pressure, and size of the machine to each other, and the ultimate power to the ultimate resistance. But it may be objected that hydraulic power is only applicable where very great resistances have to be dealt with, and that it is not at all applicable where very small degrees of power are required. Again, it may be said that there is so much trouble with the joints as to render other appliances preferable. With this question of hydraulic joints—why they give so much trouble, how they ought to be made, and what amount of endurance may be expected from them when properly constructed, we propose to deal in a simple and practical manner, leaving the other questions we have opened, for a future occasion. To all intents and purposes the joints, more particularly the working ones, are the vital parts of any arrangement of hydraulic tools. No matter how correctly the other parts of the apparatus may be designed, if the joints be defective continued annoyance will assuredly ensue. How to make really effective hydraulic joints is a secret possessed by but few, those generally made being simply barbarisms, and nothing more. No matter how well the leathers are made, or of what quality of material; no matter how carefully they are inserted, or how correctly the recesses for them are shaped, if they are called upon to encounter anything but a highly polished surface against which to work, they cannot last long. It must be borne in mind that if an unpolished surface is conducive, in the case of a metallic packing moving in contact with it, to rapid wear, it is, in the case of leather, nothing short of positive destruction. In the case of leathers under high pressures, the very specks in the metal become so many traps into which the leather is forced by the pressure, only to be rapidly torn away in small fragments. It might seem trite and unecessary to urge this truth, were it not that we have before us but too many cas s where most costly results have followed from the use of unpolished or specked surfaces. Over and beyond these causes there is still another, which is, we might almost say, universal, so seldom is care taken to avoid it, or rather, in

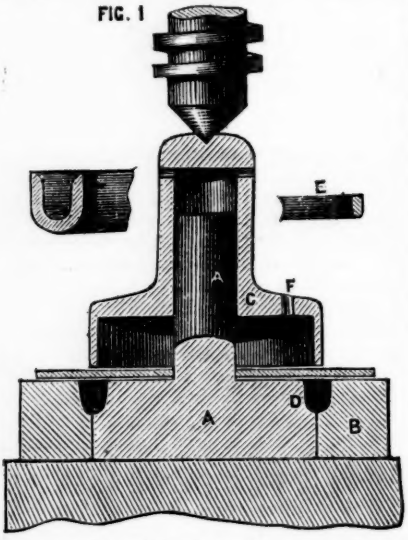
fact, so deliberately is it, as it were, cultivated. We refer to the rapid destruction of the leathers by reason of the destructive mode of insertion in recesses formed only with a view to, first, cheapness, in such a way as to positively insure the actual cutting of the leather. In making hydraulic joints three types of leathers are used, which may be classed as cup, cap, and hat leathers respectively. The cup leather is the most commonly used, and is of a form so well known as not to need any description here; the cap leather is like a hat deprived of its brim, and with a hole in the crown; the hat leather is exactly like a hat with a brim but no crown. Of course in each case the grain of the leather, that is, its outer side, must form the working surface of the hydraulic packing. It will then work to a smooth, evenly polished surface, if proper care be exercised in the finishing the metal work in contact with it. We have found considerable benefit to arise from the use of the anti-attrition powder of Messrs. Morgan Brothers, when applied with a little of the best unsalted tallow as a lubricating paste to the leathers. For the proper preparation of hydraulic leathers of various kinds, the following mode of procedure will be found completely successful. The leather selected must be the best English tannage, that is, oak-bark tanned leather. The suitable portions of leather are the hard parts of the butt for large leathers, and the best shoulders for small ones; on no account should any of the belly leather be used. With a sharp knife the whole of the fleshing, or soft inner portions, must be completely removed, great care being taken to cut the leather to a very even surface. The slighest cut below the surface will spoil the part so cut, as the leather when at work will there fail, and that soon. Having so prepared the inner side of the leather, the grain or outer side must be turned uppermost, and very carefully examined for any cuts or flaws, no matter how minute. With a pair of dividers the circles describing washers of the sizes suited to produce the required leathers, must next be drawn in. For cup and hat leathers, an inner circle will be requisite to mark the piece to be cut out at the centre. When cap leathers are required without any hole in the crown, the leg of the dividers must not puncture the centre of each washer. In this case either place a loose bit of leather, to take a centre from, or use a circular templet, and "scribe" round it. When the washers are cut they must be overhauled, to see whether the thickness is exactly equal all over each. If it be not made so, the leathers will draw unequally in the dies. The best way to make the washers is to cut squares of leather, fasten them by tacks to a piece of wood faced true in a quick lathe, and then turn them, first, to the proper evenness of thickness; secondly, cutting them to the right circular size. Of course the grain side must go towards the wooden face-plate, and the tacks must only pierce the waste corners. After the washers are thus prepared, they are to be steeped in soft water till soft and flexible.

When they have thoroughly softened, they are ready for the dies, which we shall proceed to describe. First, we will show how a really good pair of dies ought to be made for making cup leathers. The best material for dies is good hard gun-metal, as cast-iron is affected by the tannic acid, and so gets very stubborn in its behavior, so that the dies move in and out of each other with considerable friction. Besides, the iron is apt to tear the leather, since it becomes, as it were, adhesive or grating on the surface, so that the leather does not slide easily into the recess of the dies.

In Fig. 1 is shown a pair of dies of the the most improved design for making cup leathers. The figure also includes the proper means of forcing the dies home on the leather. A is the centre piece of the dies, having the projecting spindle Á, which acts as a guide to centre the leather washer and the moulding-ring; B is the outer die, fitting accurately round A. The recess, D, is formed half in each die; when this rule is not observed, there is a difficulty in removing the leathers when finished, and they are very frequently injured. When very large numbers of leathers have to be made, it is worth while to provide special means of removal from the dies. The best means consist of two rings of metal a little deeper than the dies. One ring should just pass freely round the die A, the other through the die B. The edges of these rings must be smooth and rounded. The rings merely lie on the bench beside the operator. When the dies are separated, the leather is

very quickly removed from either die by means of these rings. Should the leather, as is usually the case, be upon the die A, this die is merely dropped into the ring belonging to it. If the die B should

FIG. 1

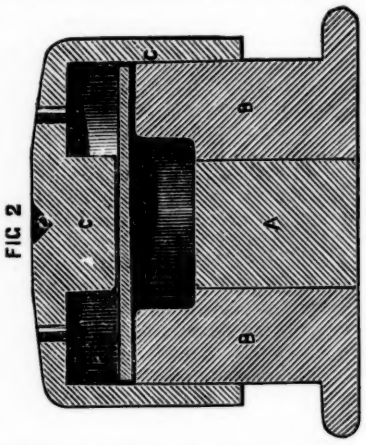


carry the leather, it is forced over the proper ring. If these rings are not provided, some blunt instrument must be used. The bell, C, fitting upon the guide, A, is in every way superior to the ring generally used for forcing the leather into the dies. The small holes at F F, are to let out the air. The arrangement of screw press for forcing home the bell, C, needs no description. The best arrangement of all others for forcing the bell home is hydraulic power itself. When a press is at hand, the leathers are best prepared by placing the dies between the plattens, and then allowing merely a slight opening of the valve to produce just a leakage into the cylinder, by which means a very slow and uniform motion may be produced.

After being forced home into the dies, the leather must be allowed thoroughly to set. When it gets firm, the pressure may be removed and the bell, C, withdrawn. Next insert the ring, E, in place of the bell, C, and with a very sharp knife or chisel, pare the leather off level. If you have no lathe you must finish the leather in the dies to the section shown at G, but if you have a lathe, the leather should be put into a split chuck, and carefully trimmed. The leather should finally be treated with tallow and anti-attrition powder, as stated above.

For making cap leathers the tools shown in Fig. 2 should be used. The plunger die C

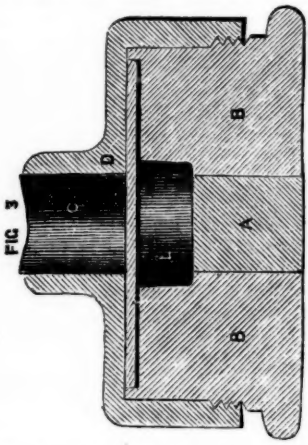
FIG 2



should be forced from the centre as before, or by a pressure applied true with the top. The centre piece A is requisite for facilitating the removal of the leather from the die B. It is necessary to make the die C with a bell guide C, to keep itself and the leather centred with B. When the leather has set, the die C is to be removed, and the plug D being inserted, the leather is to be pared level off. It should, of course, where practicable, be finished in a lathe to the section at E, and in all cases dressed with tallow and anti-attrition powder.

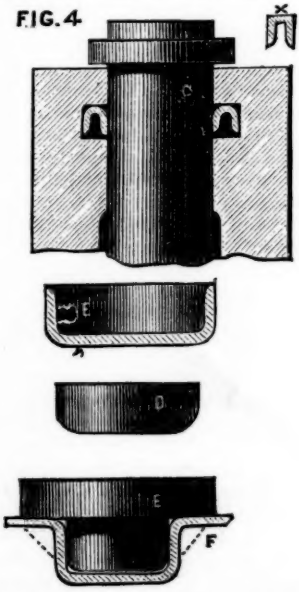
For making hat leathers the arrangement of dies shown in Fig. 3 must be used. The outer die, with its centre-piece, will be easily understood from the descriptions of the other figures. The leather L is, in this case, laid with the grain upwards, as denoted by the thick line, while in the other cases it is placed with the grain downwards. In order to form a flat brim to the leather the holding down cap D is provided to screw on to the die B. It must not hold the leather with excessive tightness, otherwise the ram C will burst the centre of the disc. The upper part of D forms the guide for the ram C. After the leather is set it should be put on to the plug E, and be pared round the edge. The crown should be cut out as at the

lines F, F. Both these trimmings are, however, better done in the lathe. Leathers thus made cannot fail to give satisfaction. It must be borne in mind that no grease or other sticky material should go



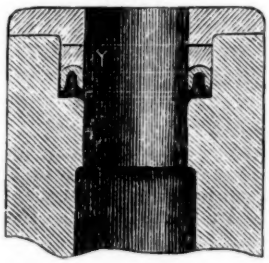
near the leathers till they are just about to be used, otherwise they will collect dust, which is, above all, to be avoided.

FIG. 4



Having made our leathers, we have only to speak about their insertion. As usually inserted (see Fig. 4), the leather is forced through a smaller diameter than its own, into a recess suited for nothing so well as its speedy destruction. Immediately the pressure is put on, the leather is forced into the shape shown at X. The result is, that, instead of wearing equally, it soon cuts through at the sharp corner produced. The proper way to insert a leather is shown at Fig. 5. Here it

FIG 5



will be seen that the leather is not put through any diameter less than its own. At Y is inserted a loose ring of metal accurately shaped to receive the back of the leather, and to form a bed for it. Thus the leather will preserve its proper shape; no sharp corners will be formed, and, therefore, the leather will really wear gradually away, in place of splitting open or tearing.

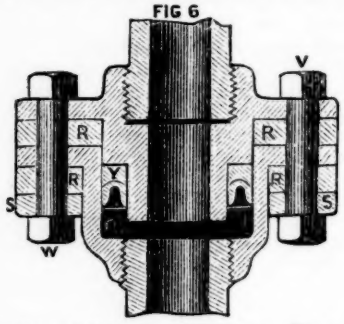
So far, we have spoken of the joints suitable for presses, pumps, and accumulators. In each of these cases there is, of course, a sliding motion through the joints. We have now to speak of those joints—in pipes, etc.—where there is no such motion to be provided for. These joints are usually made by screwing up discs of leather or lead between sockets and glands. The surfaces should have slight circular grooves turned in them. Small lengths of copper or brass tube should be put as insertions where the joint is to prevent particles of the packing from being forced into the pipes. In all cases where long lengths of pipe occur, expansion joints should be provided.

These joints should be formed on the spigot and faucet plan, with flanges held together by nuts and bolts. Between the flanges thick rubber washers should be placed, to allow of the expansion and contraction of the pipes.

The joint should be made water-tight

by a cup leather on the spigot and fitting inside the faucet; Fig. 6. shows the con-

FIG 6



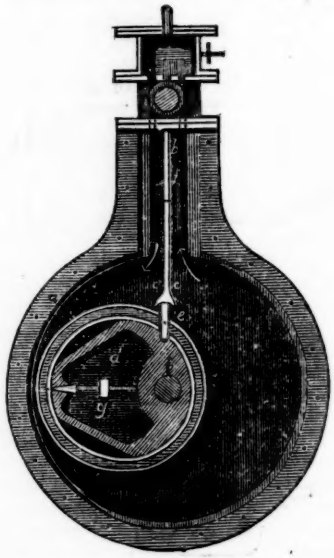
struction of this sort of joint. The ring of metal Y may, when numbers have to be made, be produced by a pair of tools in a press, a soft metal being sufficient for the purpose. In Fig. 6 R, R are the rubber washers, and S a loose flange. The bolts pass through from V to W. It will be seen at a glance that the rubber between the spigot and faucet allows for any compressive action on the joint, while the other rubber accommodates any stretching action.

These joints are easily made, as they are all simple lathe work, and where any quantity is required they can be very rapidly bored and turned with special tools. No trouble will ever occur with a series of joints properly relieved in this way. We have here indicated in detail the correct way to go to work in making hydraulic joints. Nothing here specified is at all superfluous, if a good job is to be made. In no branch of constructive art is the saw, "What is worth doing should be done well," more fully true than in the designing and constructing of hydraulic fittings.

ROTARY ENGINE.

From "The Mechanics' Magazine."

Messrs. Johnson and Gill, of Unstone, Derby, have lately patented some improvements in rotary engines and pumps. In their invention a direct rotary motion is given to the shaft of the engine, the moving parts working perfectly steam-tight with a small amount of friction. When motion is given from an external source to the shaft, the piston will act as a pump for raising or forcing water. The engine consists of a cylinder, secured on a foundation, and having a central shaft working in bearings at each end. On this shaft is mounted a circular piston, revolving eccentrically around and within the cylinder, at the top of which the inlet and exhaust pipes are applied. Between the ports a slot is cut, in which a slide has a reciprocating motion, and which, therefore, separates the exhaust from the feed, the slide also working in grooves cut within each end of the cylinder, and being attached to the piston by a saddle and knuckle joint in connection with a belt surrounding the piston, but not rotating with it. By this arrangement the eccentric motion of the piston causes the slide to ascend and descend at each revolution of the shaft, always maintaining a perfect steam stop. The piston is made in two parts, so as to insure its being steam-tight. The interior contains a spring ad-



justed to any pressure by a screw, to bind or thrust its periphery against the surface

of the cylinder, and the outer ring is divided into two parts, so that it can be sprung to the face of the side. The end also of the outer ring contains a groove, wherein the ring attached to the strap works, which connects the slide to the revolving piston. The strap works through the end of the slide, and is connected also to a spring at the top of the slide to keep it to its work. When used as a pump the chest and feed valve is not required; the feed and exhaust ports serve equally for the inlet and discharge of the water, the engine working in exactly the same manner as when steam is applied.

We show a vertical section of the engine, in which *a* is the end plate or cover of the engine, with the groove *b* cut in it for the reception of the sliding top *c*, attached to the cylindrical piston *d* by means of the jointed strap *e* and loose ring in the centre of the piston; *f* is the shaft to which the piston is fixed, and *g* is the screw rod which forces the piston against the interior of the cylinder; *h* is the feed pipe, and *i* the exhaust ports, the arrows showing the direction of the steam or water and the consequent course of the piston. The slide rises and falls within the groove and within the slot *j* in the upper part of the engine above the main cylinder, being always attached to the ring enclosing the cylindrical piston, so as to acquire a reciprocating vertical motion caused by the eccentric movement of the piston. The engine will be found applicable to driving screw propellers where direct rotary motion is desirable, as it occupies a very small space in comparison with that necessary for a reciprocating engine.

NOTE ON THE EARLIER HISTORY OF THE SCIENCE OF HEAT.

By GEORGE FARRER RODWELL, F. C. S.

From the "Chemical News."

As a supplement to the lectures on "Heat" which have recently appeared in this journal, it will not, I think, be out of place to give a short account of some of the principal facts connected with the earlier history of the science of Heat. In doing this it will be impossible to preserve any great continuity, my object being rather to indicate some of the old scientific treatises in which experiments are detailed, and to supply the student with a means of reference which the foregoing lectures of necessity could not afford. The memoirs and the works of recent writers on Heat are so well known and so much at the command of all who desire to pursue the study, that it will be sufficient to mention the names only of Cazin, Clausius, Despretz, Franz, Guthrie, Helmholtz, Herschell, Hirn, Joule, Knoblauch, Kopp, Magnus, Mayer, Melloni, Pouillet, Regnault, Balfour, Stewart, Tait, Thomson, Tyndall, and Wiedemann.

It is difficult to say when the science of Heat properly, so-called, first arose. It is certainly a younger science than Statics, Dynamics, Hydrostatics, Hydrodynamics, Pneumatics, Optics, Static Electricity, and Magnetism. I question whether Acoustics can be added to this list, although it has ever had the stimulating effect of the art of Music, which, in its turn, had the stimulating effect of Church Ceremonial, and attained some perfection in the 16th century, and much perfection in the 18th. M. Libri very truly says, "Les recherches des Pythagoriciens sur les vibrations des corps sont les plus anciennes expériences de physique qui soient parvenues jusqu'à nous;"* but we must bear in mind that the results of these experiments were applied to Music as an art, rather than to Sound as a science. Omitting, then, the question of the precedence of Acoustics, we yet perceive that Heat is among the younger of the sciences. This arises from the fact that, until late in the last century, heat was regarded as a chemical agent, and became merged more or less into chemistry proper. Separate treatises on Heat were unknown, but every chemical work devoted some chapters to the acts and operations of fire. "Car en effet," as Lemery remarks, "c'est par le moyen du feu qu'on vient à bout de presque toutes les opérations chimiques." Hence arose such expressions as "Chymic heat," "ye hete of ye chimists fornace," etc., to designate intense degrees of heat. Then, again, the theory of Phlogiston is essentially a heat

* "Histoire des Sciences Mathématiques en Italie." 1838.

theory in one sense, but it has ever been regarded as a chemical theory, because the action of heat is so closely associated with the majority of chemical operations that the scientific cared not to step aside to examine the nature of heat itself, preferring to leave the examination of the cause, to study that of the ultimate effect. Boerhaave in his admirable "Elementa Chemiæ," the most extensive chemical work which had up to that time (1732) appeared, devotes a good deal of space to the "instruments" of chemistry, "beginning," as he remarks, "with fire, by reason that no chemical operation ever was, or can be hereafter performed, to which fire does not contribute." (It may be remarked here that *fire* and *heat* were often used as almost synonymous terms by old writers; thus Boerhaave says "Fire expands even the hardest bodies.") I imagine that Francis Bacon's little treatise "De Formâ Calidi," was the first attempt to raise Heat into a separate science. It was an utter failure, yet the attempt is to be applauded, for it was the lack of observation and the paucity and obscurity of the knowledge possessed at that time by the world at large in regard to heat, that of necessity resulted in the failure. What are we to say to such an assertion as the following? "Omnino calor cælestium augetur tribus modis; videlicet ex perpendiculo, ex propinquitate sive perigæo, et ex conjunctione sive consortio stellarum." S. Gravesande in his excellent "Physices Elementa Mathematica"—one of the best illustrated works on Physics which has ever appeared, and which may even now be consulted with advantage—gives 45 pages ("Editio tertia, duplo auctior," 1742) to Heat, and 234 to Light. He commences the "Liber de igne" with the very pertinent remark, in his blunt rugged Latinity, "Pauca de igne norunt philosophi; multa ipsos latent," adding very sensibly (and it is to be wished that his example were more often followed) "Hypotheses non fingam; generaliora, que experimentis deduci posse mihi videntur, eo quo potere meliore ordine, dicam."

The production of fire by the refraction and reflection of the rays of the sun was well known to the ancients. The sacred fire of Vesta was re-kindled by the rays of the sun reflected from a metallic mirror, and, according to Pliny, the mirror was sometimes replaced by a glass globe filled with water. Aristophanes clearly alludes to the use of glass lenses as burning glasses, in the Νεφελαι.

Lactantius, in his curious treatise "De ira Dei," mentions that a glass globe filled with water and placed in the rays of the sun, will kindle fire even in the coldest weather.* Baptista Porta in his ever new, ever interesting treatise, "Magiæ Naturalis"—which links the magic of Art of Eastern civilization with the magic of Nature of Western civilization, Chaldæan mysticism and Theurgy with the Realism of the Renaissance—Baptista Porta mentions the fact that heat, sound, and cold may be reflected by mirrors in the same manner that light is reflected. As a delicate instrument of observation in the case of the reflected cold, Porta placed his eye in the focus of the mirror, as, some two and a half centuries later, Dr. Tyndall placed his eye in a focus of dark heat rays in order to see whether any light accompanied the heat rays. Porta's account is interesting; it occurs in the seventeenth book, and is entitled "Calorem, frigus, et vocem speculo concavo reflectere." "Si quis candela in loco," he continues, "ubi spectabilis res locari debet apposuerit, accedet candela per aerem usque ad oculos, et illos calore et lumine offendet, hoc autem mirabilius erit, ut calor, ita frigus reflectitur, si eo loco nix objiciatur, si oculum tetigerit, quia sensibilis etiam frigus percipiet." Somewhat later Hamerus Poppius calcined antimony "per radios solares" with the use of a lens, in order to determine whence came the gain of weight. Bonaventure Cavalieri, the discoverer of infinitesimals, writing in 1632, states that he was able to inflame dry substances by reflecting the heat emitted by charcoal fire by means of a spherical speculum; by using a parabolic reflector he produced the same effect at a distance of 5 ft., a small fire of wood being the source of heat. He recommends a hyperbolic reflector, and asserts that the impressions of heat, cold, sound, and

* Lactantius was born about A. D. 250; he died in 326. His words were amongst the first printed in Italy; the first edition issued from the press of the monastery of Subiaco as early as the year 1465, while a second issue appeared in Rome in 1468, in both cases it will be remembered before a single book had been printed in this Island. The passage alluded to above is taken from the 10th chapter, entitled "De mundi ortu, et rerum natura, et Dei providentia," and is as follows: "Omitto silicem, ac ferrum. Orbem vitreum plenum aquæ si tenueris in sole, de lumine, quod ab aqua refugit, ignis accenditur etiam in durissimo frigore."

scent move in straight lines.* Athanasius Kircher has also treated of reflection in his "Ars Magna Lucis et Umbræ."

The term "radiant heat" was introduced by Scheele in his treatise entitled "Luft und Feuer." Pictet in his celebrated "Essais Physiques sur le Feu"(1790)demonstrated the enormous velocity of propagation of radiant heat; he also treats of absorption and reflection of heat, and of latent and specific heat. Prevost made known his "Theory of Exchanges" in 1791 through the medium of the "Journal de Physique."

Black discovered "latent heat" about the year 1760; his pupil Irvine introduced the term "capacity for heat," while Gadolin replaced it in 1784 by the term "specific heat." In connection with the determination of the specific heats of various substances, the following names are most prominent: Wilke, Lavoisier, Laplace, Kirwan, Dalton, Dulong, Petit, De la Rive, Regnault, Favre, Silbermann, Bérard, De la Prevostaye, and Desains.

As regards the air thermometer, I am inclined to think that Galileo invented it about the year 1597; some attribute it to Sanctorio of Padua, others to Cornelius Drebbel of Alcmaer, while others, again, maintain that it was discovered by each of these men independently of each other. Some of the members of the Accademia de Cimento first constructed a fluid thermometer in 1655 or 1656. Edmund Halley introduced mercury in the place of alcohol. Otto von Guericke was the first to take the freezing of water as the lowest limit of the scale, while Renaldini, in 1694, proposed the boiling and the freezing points of water as the opposite limits of the thermometric scale. A kind of rude differential air thermometer is mentioned by Sturmius in his "Collegium Experimentale sive Curiosum" (1676). Sir John Leslie described the differential air thermometer which bears his name, in 1804, in his "Experimental Enquiry into the Nature and Propagation of Heat."

Leslie's principal work is his "Essay on Heat," in which he described the radiative and absorptive power of various substances, and determined the laws which regulate the radiation of heat. He maintained, however, that air is as essential to radiation as it is to convection.

The subject of the conduction of heat was discussed at some length by Lambert in his "Pyrometrie," published in 1779, but the earlier mathematical treatment of the subject is due to Fourier, and is detailed in a paper entitled "Théorie Analytique de la Chaleur," communicated to the Académie des Sciences in 1807. His definition of conductivity is extremely lucid, and he has treated of the cooling of an uniformly heated sphere with great ingenuity and elaboration. Poisson and Carnot have also applied the higher mathematics to the elucidation of various questions connected with the science of heat, and in our day Helmholtz, Clausius, and Thomson.

Mariotte and Hooke observed that glass cuts off many of the rays of radiant heat. M. De la Roche discovered, in 1812, that radiant heat, which has passed through glass, has lost the rays which glass most readily intercepts, and that, as the temperature of the radiating source rises, so does the readiness of the radiant heat to pass through glass increase. Nobili and Melloni worked together on the subject of radiant heat. The former invented the thermopile, while the latter made the important discovery that rock-salt is very transparent to all kinds of heat, and that, by using lenses and prisms of rock-salt, dark heat rays may be refracted exactly in the same manner that light is refracted by glass. These results were published in the celebrated treatise entitled "La Thermochrose, ou la Coloration Calorifique," and were at first received with some credulity by the Parisian *savans*.

The most notable experiments in connection with the polarization of heat were made by Bérard in 1812 ("Mémoires d'Arceuil," vol. iii.), and later by Forbes.

The Abbé Rochon endeavored to determine the comparative heating effects of the various colored rays of the spectrum as early as the year 1776; he employed a flint-glass prism and an air thermometer, and reckoned the heating power of the red rays to be about eight times greater than that of the violet. In 1798 Leslie (?), by using a differential arr thermometer, found the calorific energies of blue,

* Cavalieri was born in Milan in 1598; he died in 1647. The above is extracted from a work entitled "Lo specchio Ustorio: onero trattato delle sottioni Coniche et alcuni loro mirabili effetti intorno al lumo, caldo, freddo, suono, et moto ancora." Bologna, 1632.

green, yellow, and red to be as 1 : 4 : 9 : and 16. In 1800, Sir William Herschell employed a small mercurial thermometer for the same purpose, and arrived at the conclusion that the hottest part of the spectrum is beyond the red rays. A detailed account of recent research on this subject (especially of the "long spectrum of the electric light") will be found in Tyndall's work "On Heat treated as a Mode of Motion."

The history of heat theories has not been alluded to above because the history of the kinetic theory was discussed at some length in the first of the foregoing lectures,* and I have elsewhere† treated of one of the phases of the material theory. Bergman's "De Materia Caloris" may also be consulted by those who are interested in this part of the subject. Of recent works on Heat I would especially mention Clausius "On the Mechanical Theory of Heat;" the treatise of Tait "On Thermodynamics; the "Théorie De la Chaleur" of M. Desains, and the "Thermodynamique" of M. Bertin.‡

It is hoped that the above facts—desultory though they be—may be of interest to those who desire to follow the literature of the science of Heat in greater detail than is possible in lectures, which are rather for purposes of demonstration than for the discussion of facts connected with the history of a science.

EXPERIMENTS ON IRON AND STEEL.

Translated from "Génie Civil."

M. Knut Styffe, a Swedish engineer, has published the results of experiments made by him to determine the elasticity and resistance of iron and steel.

These experiments were made to elucidate the questions to which the "Diete Nationale" had called the attention of Government, with reference to the fitness of the metals of Sweden for the manufacture of fixed and rolling material, and to their value as affected by their quality.

The experiments were generally made by traction, upon bars 1.50 metres long by 125 millim. sq.; some being rough from from the forge, others finished by the file. The traction was effected by the hydraulic press, and was measured by the aid of a lever with unequal arms. In order to allow for the influence of foreign substances, as carbon, silicium, etc., which are always found in iron, a great number of chips from the bars were analyzed.

The experiments were made upon iron and puddled steel No. 2, from different forges; upon Bessemer steel and iron of different manufactories in Sweden; on the cast-steel of Dalécarlie, on Krupp's steel, on the English Lowmoor puddled iron, and others.

It was found that at ordinary temperatures permanent elongations depend on the chemical composition, on the mode of fabrication, and the manner in which the loads are applied.

Cold hammering and cold rolling increase the limit of elasticity and resistance to rupture, but diminish elongation. The action of heat produces opposite effects.

Increase of carbon augments solidity and diminishes ductility. Phosphorus in small quantity seems to have the same effect.

Tempering raises the limit of elasticity even in iron. Tempering followed by proper annealing increases resistance to rupture; without annealing, it sensibly lessens the solidity of steel.

The co-efficient of elasticity depends less upon the composition of the metal than upon the manner in which it has been worked.

Traction and hammering diminish elasticity; heat increases it; it seems also to depend on density.

The author thinks steel, particularly Bessemer steel, superior to iron in the majority of cases.

Experiments in traction with the Carré machine, at the temperature 15 deg., 30 deg., 100 and 200 C., seem to prove that. A temperature of 100 to 200 deg. C., does not sensibly affect the resistance of steel, but augments that of soft iron.

* "Chemical News," vol. xx. p. 13. ("Am. Repr." Sept. 1869, p. 129).

† "On the Theory of Phlogiston," "Philosophical Magazine" for January, 1868.

‡ The last two treatises are published in the "Recueil de Rapporte sur l'état des Lettres et les Progrès de Sciences en France," a series of which it would be difficult to speak too highly.

The ductility of iron and steel is not diminished by cold; that of steel, and still more that of iron, is diminished by heat.

The limit of elasticity increases with cold and diminishes with heat. The co-efficient of elasticity varies slowly at high or low temperatures.

These results seem to be contradicted by the breaking of rails and of axles, which occur in winter more frequenty than in summer; but, according to the author, this is due to the rigidity of the supports.

M. Sandberg, wishing to verify the conclusions of M. Styffe, has made experiments to determine the resistance of these metals to shocks, and has met with contrary results. He thinks this shows a difference between the laws of resistance to traction and to shock.

THE UNIFORM MOTION OF WATER IN CANALS AND RIVERS.

Translated from "Polytechnisches Centralblatt."

On the 31st of October, 1868, at Bern, Ganguillet, civil engineer, presented a paper containing a contribution to the determination of a formula for the uniform motion of water in canals and rivers. The author, in a review of the history of this question, mentions Guglielmi, Pitot, Daniel Bernouilli, Brahms and Dubuat; he then gives the formula due to Prony. $RH = aV + bV^2$, in which R is the hydraulic depth (mean radius), *i. e.*, the sectional area of the water divided by the wet perimeter; H, the fall or inclination of the surface of the water, and v the mean velocity of the water; $a = 0.000044^m$; $b = 0.000309^m$. These co-efficients were determined by Prony from 30 measurements by Dubuat and one by De Chezy. Eytelwein obtained from these 31 French measurements, and 55 made in Germany, by Brunnings, Woltmann and Funk, $a = 0.000024$ and $b = 0.000366$. Brahms, of Germany (1753), and Chezy, of France, (1755), found for velocities greater than one meter, $RH = bV^2$; in which $b = 0.0004$.

The results of experiments on many large canals, streams and conduits, gave rise to a well-founded want of confidence in the adequacy of these formulas. Darcy, *Inspecteur General des Ponts et Chausées*, who built the aqueduct at Dijon, found, by experiments on pipes, that the condition of the interior wall affects the discharge of water; for example, that the co-efficient of resistance in old pipes is about as large as in new. Darcy and Bazin, by a series of experiments made in conjunction, proved that there is a similar effect of the condition of the wall upon the flow of water in canals. In these experiments the velocities were directly determined by the improved Pitot's tube, and at the same time the quantity of water admitted into the canal by a sluice was accurately determined. Bazin found that in the formula

$$V = C\sqrt{RH}$$

the co-efficient is not constant, but a function of R, and that in general it increases with H, but that the influence of H, and that of the profile of the canal, could be neglected; so that he deduced the formula

$$RH = \left(a + \frac{b}{R}\right)v_2$$

and determined the following values of *a* and *b* in meters:

(1.) Canals carefully lined with planed boards, or with pure cement, $a = 0.00015$, $b = 0.0000045$.

(2.) Canals with lining of rough boards, hewn stone or brick, $a = 0.00019$, $b = 0.0000133$.

(3.) Canals with lining of rubble, $a = 0.00024$, $b = 0.00006$.

(4.) Canals in earth, $a = 0.00028$, $b = 0.00035$.

Kutter, in Bern, made measurements in a stream in Switzerland, and found $a = 0.0004$, $b = 0.0007$.

At the time of Bazin's experiments, Capt. A. A. Humphreys and Lieut. H. Abbot, a Commission of the United States Government, made hydraulic surveys on the Mississippi, from the mouth of the Ohio to New Orleans. The Mississippi between these limits has an area of overflow which is nearly equal to the area of Germany. The channel has a mean breadth of 1,000 to 1,500 meters, and a maximum depth of 45 meters. Below the mouth of the Ohio the difference between high and low water is 15 meters, and the

greatest discharge is estimated at about 33,000 cubic meters in a second, with a mean velocity of 2.10 meters. The Commission, working from 1850 to 1860, considered no velocity-formula sufficient for their purpose, and that a direct determination of the law of flow of the river was necessary. Pitot's pipes and Woltmann's Tachometer could not be used in finding the mean velocity. Double floats were therefore employed, the heavier moving in the lower current, the lighter in the surface; both connected by a small cord. The path of the float was determined by means of two theodolites at the ends of a base-line on shore. By this means it was found that the plane of maximum velocity coincided with the free surface when a strong wind was blowing down stream; but, in case of a gentle wind blowing down, it was 0.30 of the total depth below the surface; while in case of a wind blowing up stream it fell below the middle.

Humphreys and Abbot deduced from their measurements that the diminution of velocity, both vertically and horizontally, was indicated by a parabola, the axis of which passes through the point of greatest velocity, having for abscissas the velocities and depths for ordinates. Bazin and others find the same law. The American observers refer the retarded velocity at the surface in still air to the friction of the air; but Bazin has proven by experiment, that in small canals such friction is not perceptible, though the greatest velocity is not always at the surface.

In the formula of Humphreys and Abbot

$$V = \left[\sqrt{0.0025\,m} + \sqrt{68.7\,R_1\sqrt{H}} - 0.05\sqrt{m}\right]^2$$

$$m = 0.933 \div \sqrt{R} + 0.457$$

V and R having same meaning as before, R_1 denotesthe sectional area divided by its perimeter. As both functions of m have a small value, Grebenau, a Bavarian engineer, rejects them and puts

$$V = K_1\sqrt{R_1\sqrt{H}} \quad \text{or} \quad V = K\sqrt{R\sqrt{H}}$$

since R_1 is nearly the half of R, and, therefore, $K = K_1 \div \sqrt{2}$.

The limits of the change of value in K, resulting from the neglected functions of m, are very near each other. Kutter's comparison of this simple formula with the original, both for falls with great depth and small incline, and the converse, shows that K lies between 5.7 and 5.0 meters.

The American formula is suited to the results of the measurements on the Mississippi, and agrees with the results which Grebenau obtained from his experiments on the Rhine and the rivers of Bavaria, and does not differ greatly from the general results of measurements on waters of small incline, and depth of more than 2 meters. Kutter and Ganguillet made measurements in the summer of 1867, on canals with great slope, at Merlingen, at a time when the flow was a little greater than usual (131 cub. ft. a second). They found the mean velocity V determined by observation, and V, as calculated by the American formula, as follows:

(1.) At the Grünbach sluice:
H = 0.083 to 0.107; R = 0.108 to 0.198.
V = 3.6 to 5.8m.; V_1 = 0.8 to 1.3m.

(2.) At the Gerbebach sluice:
H = 0.112 to 0.237; R = 0.059.
V = 2.6 to 3.1m.; V_1 = 0.7 to 0.8m.

(3.) At the Gontenbach sluice:
H = 0.042 to 0.046; R = 0.098 to 0.112.
V = 2.9 to 3.3m.; V_1 = 0.7 to 0.8m.

(4.) At the Alpbach sluice:
H = 0.023 to 0.032; R = 0.209 to 0.229.
V = 2.4 to 2.6m.; V_1 = 0.9 to 1.0m.

In case of great fall the American formula, therefore, gives too small velocities. The same is true of Bazin's formula. This answered very well for small streams with falls greater than 1 to 100, and gives useful results for European rivers less than 6^m deep.

The experiments at Merlingen fully prove the influence of the roughness of the wetted surface. At the Gontenbach sluice, where the masonry is carefully laid with large, fair-worked stones, the actual velocities roughly agreed in the average with the velocities calculated by Bazin's formula for cut-stone and quarry-stone; while at the Alpbach sluice, where the work is of rough stone and damaged, the formula for rough stone gives too large results, and a roughness between that of rubble and earth must be assumed.

Applying Bazin's formula to the Mississippi, where the fall is as low as 0.0000034, the results are too small. This formula gives the greatest velocity if $R = \infty$, because in that case

$$a + \frac{b}{R} = a;$$

hence, we always have

$$V < \sqrt{\frac{R\,H}{a}},$$

Taking the value given for the smoothest walls, $a = 0.00015$, we have

$$V < 81.5\sqrt{R\,H}.$$

To a fall $H = 0.0000038$ and a hydraulic depth $R = 22.7^m$, corresponds (*e. g.* in the Mississippi) the actual mean velocity 1.21^m; hence

$$\sqrt{R\,H} = 0.009282, \text{ and } V = 130\sqrt{R\,H}.$$

The formula of Bazin therefore gives too small velocities, while the American is exact, since it gives

$$V = 5.7\sqrt{R\,H} \div (0.0000038)^{\frac{1}{4}} = 130\sqrt{R\,H}.$$

The discrepancies between the formula of Bazin and that of Humphreys & Abbot are accounted for by the fact that they correspond to extreme ratios, as in each a function of R or of H was neglected, as the influence of either was found of little importance. The author of the paper, therefore, concludes that the velocity does not always vary, either as the square root of R, as in the American formula, or as the square root of H, as in the French formula. Assuming

$$V = a\,H^x\,R^y,$$

then, if the cases represented in the above formulas be regarded as extreme, x must vary between $\frac{1}{4}$ and $\frac{1}{2}$ and y between $\frac{1}{2}$ and 1, whether H and R be great or small. A single formula with constant co-efficients of H and R cannot correspond in all cases to the results of measurements. Attemps to construct such formulas have been made by Gaukler, in France, and lately by Hagen, in Berlin. A general formula, from the results of Bazin and Mississippi experiments, has been constructed by Kutter & Gauguillet, which will be published at a future time.

THE INTENSITY OF ELECTRIC BATTERIES.

Translated from "Annales de Genie Civil."

At a late session of the Academy of Sciences of Paris, M. Th. de Moncel presented a very interesting paper on the coupling of a series of piles. The learned electrician had already, in two previous memoirs, demonstrated that the intensity of the resultant current of a series of piles is given by the formula:

$$I = \frac{n\,E}{a\,R + b\,r}$$

in which a denotes the number of groups in the series, and b the number of elements in each group. From this, it can be shown (the maximum value of I being reached when $a\,R = b\,r$) that the number of groups which must be joined in tension that a given pile may furnish for a given circuit, r, its maximum effect, is indicated by the formula:

$$a = \sqrt{\frac{n\,r}{R}},$$

while the number of elements of each group united in quantity is given by the formula:

$$b = \sqrt{\frac{n\,R}{r}}.$$

It was also observed that each of these couplings, being algebraically compared with the couplings made all in tension, or all in quantity, furnish two limits at which the electric intensities become equal, and that these limits were reached by 3, 4, 5, &c., elements united in quantity:

(1.) *In the pile disposed in tension*, when the resistance of the circuit r is equal to $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c., of the total resistance of the pile.

(2.) *In the pile disposed for quantity*, when the resistance of the circuit is $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c., of the resistance of a single element.

Again, it was seen that between these limits there was a gain in disposing the pile in series of 2, 3, 4, 5, &c., elements united in quantity, when the values of r, being less than

$$\frac{n\,R}{2}, \quad \frac{n\,R}{3}, \quad \frac{n\,R}{4}, \quad \frac{n\,R}{5}, \ldots\ldots$$

are greater than

$$\frac{R}{2}, \quad \frac{R}{3}, \quad \frac{R}{4}, \quad \frac{R}{5}, \ldots\ldots$$

These results being only the consequence of the comparison of combinations in series disposed for tension and quantity, there would be nothing to show

whether, in the comparison of the various arrangements in series, one would not find for the limiting values of r (in the conditions of maximum) dispositions more favorable to each of the syst ms of groups. M. de Moncel has undertaken to determine this.

He begins with the formulas:

$$a = \sqrt{\frac{n\,r}{R}}, \qquad b = \sqrt{\frac{n\,R}{r}}$$

and he finds values of r corresponding to the different systems of couplings at their maximum conditions. He finds:

(1.)	That if	$a = n$,	$r = n\,R$
	"	$a = \frac{n}{2}$,	$r = \frac{n\,R}{4}$
	"	$a = \frac{n}{3}$,	$r = \frac{n\,R}{9}$
	"	$a = \frac{n}{4}$,	$r = \frac{n\,R}{16}$
	....	....	....
(2.)	"	$b = n$,	$r = \frac{R}{n}$
	"	$b = \frac{n}{2}$,	$r = \frac{4\,R}{n}$
	"	$b = \frac{n}{3}$,	$r = \frac{9\,R}{n}$
	"	$b = \frac{n}{4}$,	$r = \frac{16\,R}{n}$

The conclusion is, that the resistances of the exterior circuit, the most favorable to the grouping of the pile in double, triple, quadruple, etc., elements, correspond to the number expressing the total resistance of all the elements of which the pile is composed, divided by the square of the number of elements which constitute each of the groups of these different combinations.

Upon this principle, using the number 931, which represents the resistance of a Daniell element, expressed in metric units of a telegraphic wire of 4 millimetres, we find that for a Daniell of 12 elements the best conditions of use are:

(1.) In 12 series of simple elements, when r = 11172m.
(2.) In 6 series of double elements, when r = 2793m.
(3.) In 3 series of triple elements, when r = 1241m.
(4.) In 4 series of quadruple elements, when r = 698m.
(5.) In 2 series of sextuple elements, when r = 310m.
(6.) In 1 series of 12 elements in quantity, when r = 77m.

Considering the question under another point of view, it is also seen that when r is equal to

$$n\,R, \quad \frac{n\,R}{2}, \quad \frac{n\,R}{3} \ldots, \quad R, \quad \frac{R}{2}, \quad \frac{R}{3}, \quad \ldots$$

a does not correspond to

$$n, \quad \frac{n}{2}, \quad \frac{n}{3} \ldots\ldots,$$

as the limits in question seem to indicate, but to

$$n, \quad \frac{n}{\sqrt{2}}, \quad \frac{n}{\sqrt{3}}, \quad \ldots \quad \sqrt{n}, \quad \sqrt{\frac{n}{2}}, \quad \sqrt{\frac{n}{3}} \ldots$$

while

$$b = 1, \quad \sqrt{2}, \quad \sqrt{3} \ldots.$$

In the first memoirs M. de Moncel has shown the values of a and b, corresponding to a given intensity I. These formulas are:

$$a = \frac{2\,I\,r}{E}, \qquad b = \frac{2\,I\,R}{E},$$

But, that these may be applicable, r must be less than $n\,R$. For it is only when b is greater than unity that the maximum is reached when $a\,R = b\,r$.

IRON AND STEEL NOTES.

FURNACES FOR MELTING STEEL.—Mr. J. Suter, of Hereford, and Mr. T. Hinde, of Fownhope, near Hereford, have patented an invention which consists in constructing furnaces for melting steel and for other purposes, and in the combustion of fuel in the furnaces, by which means great economy of fuel is said to be effected, a higher temperature obtained, and great control over the action of the furnaces at the same time secured. These improvements are also applicable to the furnaces of steam boilers. The furnace is constructed of three principal parts, namely, of a gas-generating chamber, a combustion chamber, and a superheating chamber. In the first or gas chamber, the solid fuel is converted into gaseous fuel by being ignited and supplied with a sufficient quantity of air to convert the carbon of the fuel into carbonic oxide. The second chamber of the furnace consists of a reverberatory chamber, into which gaseous fuel produced in the first chamber, mixed with the requisite quantity of air for combustion, is burned. In the third or supplementary chamber, the gaseous fuel is heated prior to being burned in the combustion chamber. The gas-generating chamber is of iron, lined with fire-brick, and having an opening at the bottom through which the clinker can readily be removed, or the clinker may be fluxed out by charging a little lime with the fuel.

Fuel is supplied to the gas-generating chamber by an opening at top closed by a valve, which permits of the introduction of the fuel without material loss of gas. The requisite quantity of air is introduced into the gas-generating chamber from a fan, and is delivered into the chamber by a tuyere. In order the more effectually to bring the air into contact with the ignited fuel where the fuel is very

small or in a fine state of division, it is delivered into the chamber by a series of small openings in the tuyeres instead of by one or two large openings. The combustion chamber, in which the gaseous fuel is burnt, and in which the steel is melted or the other operations of the furnace performed, has a size and form suitable to the particular use to which the furnace is applied. The gaseous fuel is heated before it is introduced into the combustion chamber, so as to raise its temperature and thereby produce a more intense heat in the furnace, either by passing it through heated tubes or by allowing it to undergo combustion. When the gaseous fuel is heated by the former method, a heating chamber is constructed above or in connection with the combustion chamber, through which heating chamber the waste heat from the combustion chamber is passed. Fire-clay tubes, passing through the heating chamber, conduct the gaseous fuel to the combustion chamber, which gaseous fuel is superheated in its passage through the tubes. When the heating of the gaseous fuel is effected by its own combustion, atmospheric air is mixed with it and it is ignited. The gaseous fuel which has thus been burned, is passed through ignited carbonaceous matter, whereby it takes up carbon, and becoming revivified or reconverted into combustible gas, passes to the combustion chamber strongly heated and with its full combustible power. By heating gaseous fuel in the ways described, an intense heat is produced in the combustion chamber. When the furnace is used for reducing metallic ores, the gaseous fuel is not superheated by the waste heat from the combustion chamber, but the gaseous fuel passes into and through the combustion chamber to the superheating chamber and is burnt in the superheating chamber.

In applying these improvements to the furnaces of steam-engine boilers, the superheating of the gaseous fuel is unnecessary. By varying the quantity of air mixed with the gaseous fuel during combustion, the character of the flame produced may be varied so as to possess either a reducing or an oxidizing action. As a convenient means of ascertaining the character of the flame, the inventors employ in the furnace a small lump of coal and a lump of peroxide of manganese. When the flame has an oxidizing character, the gaseous fuel volatilized from the coal burns with a bright light, while there is no apparent action on the manganese. When the flame has a reducing character, there is no flame from the coal, but the lump of oxide of manganese becomes intensely ignited by the combustion which takes place on its surface between the oxygen evolved from it and the carbonaceous matter of the gaseous fuel.—*The Mechanics' Magazine.*

NOTES ON THE FRENCH IRON TRADE.—The Paris, Lyons, and Mediterranean Railway Company has just let a contract to Messrs. Schneider, of Creusot, for 5,000 tons of steel rails, at a price of £12 12s. a ton at the works, subject to the condition that a deduction will be made from the price after the expiration of Mr. Bessemer's patent right; this deduction is estimated at £1 3s. 4d. a ton.

The Northern Railway of France has decided upon replacing with steel, the whole of the iron rails upon the line, at an estimated cost of £52,000.

Partial contracts have recently been let for the iron work of a large covered market in Naples, designed upon the plan of similar buildings in Paris. The wrought-iron work, to the amount of about 1,500 tons, is divided amongst two or three different works. The contract for the cast-iron columns, amounting to some 2,500 tons, are not yet given out.

The bridge and viaducts, 53 in all, on the Latour and Milhan section of the line between Rodez and Montpelier, are in course of construction by Messrs. G. Eiffet and Co., of Lavallois, Paris.

The new "Société des Forges et Chantiers de la Mediterrannée" has in course of construction an iron floating dock for the Viceroy of Egypt. The following are its principal dimensions:

	ft.	in.
Total length	463	5
Width inside	78	$8\frac{7}{8}$
Width of side chambers	9	10
Total width	88	6
Depth of the bottom framing	8	$2\frac{3}{4}$
Height from bottom framing to top of dock	28	$10\frac{3}{4}$
Total height	36	1

The bottom skin of the dock is made of two thicknesses of $\frac{7}{16}$ in. plate; the sides of $\frac{5}{8}$ in. plates at the bottom, decreasing gradually to $\frac{3}{8}$ in. at the top. The plates of the framing are $\frac{1}{2}$ in. thick. The strakes are $24\frac{1}{2}$ in. wide, and at intervals of 16 ft. 4 in. they are strengthened by vertical angle-iron, strengthened with gusset plates. The plates forming the bulkheads are $\frac{5}{8}$ in. thick. The total weight will be about 4,500 tons.

The iron bridge to cross the Seine at Vernon, and to carry the Gisors and Vernon Railway, is in course of construction. The total length of the bridge is 705 ft., and it is being constructed complete on the bank, upon a platform, from which it will be launched across the river. The weight of the structure will be about 400 tons.

The suspension bridge across the navigable arm of the Seine at Melun, carrying the Imperial road, which connects Brie with Froissard, is about to be removed, and an ornamental cast-iron arched bridge in two openings will be erected in its place. The estimated cost is £9,200.—*Engineering.*

IRON AND STEEL CRYSTALS.—M. Schott, of Ilsenberg, has made many microscopical examinations of the structure of steel and iron. He maintains that "all crystals of iron are of the form of a double pyramid, the axis of which is variable, as compared with the size of the base. The crystals of the coarser kinds, as compared with those of the finest qualities of crystalline iron, are of about twice the height. The more uniform the grain, the smaller the crystals, and the flatter the pyramids, which form each single element, the better is the quality, the greater is the cohesive force, and the finer the surface of the iron. These pyramids become flatter as the proportion of carbon contained in the steel decreases. Consequently in cast-iron and in the crudest kinds of hard steel, the crystals approach more the cubical form, from which the octahedron proper is derived, and the opposite extreme or wrought-iron has its pyramids flattened down to parallel surfaces or leaves, which in their arrangement produces what is called the fibre of the iron. The highest quality of steel has all its crystals in parallel positions, each crystal filling the interstices formed by the angular sides of its neighbors. The crystals stand with their axes in the direction of the pressure or percussive force exerted upon them in working, and consequently the fracture shows the sides or sharp corners of the

parallel crystals. In reality, good steel shows, when examined under the microscope, large groups of fine crystals like the points of needles—all arranged in the same direction and parallel.—*Journal of Applied Chemistry.*

ARTIFICIAL PORPHYRY FROM IRON SLAGS.—At the iron-works of Aulnoye, in Belgium, the slag is utilized by casting it into slabs for pavements, garden rollers, and other things. For the former purpose, moulds are excavated in the ground around the furnaces of sufficient extent to receive all the slag running from them, and trenches are cut to carry the liquid slag. The only precaution to be taken, we are told, is to cause the slag to run under the vitreous layer, which solidifies at the beginning of the running, and to keep the moulds warm, so that the slabs may not solidify too rapidly. For this purpose it is often necessary to cover up the trenches and moulds with cinders and small coal. The cooling should, indeed, be made to occupy several days; and, in that case, there will be found under the vitreous crust a compact homogeneous slab, in appearance very much resembling natural porphyry. The masses are often divided by fissures, but the pieces can be dressed and trimmed into blocks for paving. To obtain sound rollers, it is necessary to take especial care in the cooling and solidifying. It is hardly necessary to add that the slags employed for these purposes must be solid and lasting, and not at all brittle.

OBTAINING MALLEABLE IRON OR STEEL FROM CAST-IRON.—The invention of Mr. J. B. Spence, of Manchester, relates to that method of obtaining malleable iron or steel from cast-iron which is now known as the Heaton process, or to other processes in which nitrate of soda, or other similar chemical salts, are used for oxidizing substances combined with the iron, and consists in a method of using the said salt, whereby its decomposition is to a certain extent retarded. For this purpose he brings the nitrate of soda, or other salt, into a more or less solid body before the melted iron is allowed access to it. This solidification may be effected by pressure, by fusion, or by other means. The process of solidification may be effected in the chamber which is used for receiving the converted iron, or in separate moulds, and Mr. Spence proposes to bind the edges of the consolidated cake of the salt to prevent its rising, or the passage of the metal beneath it by bevelled edges, projections, or other such means. In order when desired to weaken the power of the chemical agents, he adds thereto any suitable diluents.—*Mining Journal.*

CANADA RAILS.—The chairman of the Grand Trunk line, says, with regard to the Toronto rolling mills, it has been found that rails rolled there would last as long as three or four times the number of rails shipped from England to Canada during the last 3 or 4 years. The Toronto re-rolled rails are acknowledged to be the best rails that can be made in Canada, and a few weeks before he left Canada, as a great favor, they allowed the Great Western of Canada Company to have 300 tons of rails re-rolled at the company's Toronto rolling mills.

RAILS IN FRANCE.—A table prepared in illustration of the production of rails in France during the last ten years presents the annexed results: 1859, 101,426 tons; 1860, 121,438 tons; 1861, 164,371 tons; 1862, 216,175 tons; 1863, 226,948 tons; 1864, 215,983 tons; 1865, 184,131 tons; 1866, 159,061 tons; 1867, 154,351 tons; and 1868, 202,204 tons. The average price per ton in 1859 was £10 2s. per ton, while in 1868 it had fallen to £7 2s. per ton.

BESSEMER RAILS IN FRANCE.—The consumption in the first six months of this year amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1868; it is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last two or three months by the great French railway companies.—*Engineer.*

IRON IN GREAT BRITAIN.—The furnaces in blast in 1868 were 560; pig-iron in Great Britain amounted to 4,970,206 tons, an increase of 209,183 tons over 1867. In England the make was 2,970,905 tons, an increase of 159,959 tons; in Wales and Monmouthshire, 931,301 tons, an increase of 12,221 tons; in Scotland, 1,068,000 tons, an increase of 37,000 tons.

RAILWAY NOTES.

THE FESTINIOG RAILWAY.—The little Festiniog Railway of 2 ft. gauge, presents a striking example of commercial success, and did its yearly accounts come before the general public they might, perhaps, create a feeling of astonishment. The original capital of the company was £36,000, applied to a line of 13 miles, but, their borrowing powers being exhausted, they have since almost reconstructed their line, erected workshops, manufactured their rolling stock, etc., wholly out of revenue, until the whole expenditure now stands at about £86,000, the company having this year obtained powers to capitalize the revenue thus applied.

In the year ending June 30th, 1868, the train mileage was 46,732 miles, averaging six trains each way daily for the 313 working days of the year, or, say, 1878 down trains loaded with slates. The weight of slates taken into Portmadoc was 112,052 tons, equal to nearly 60 tons per train, while 14,693 tons of merchandise were carried on the return trips, besides passengers, both ways, paying £3,381. The slate trucks, of course, return empty from Portmadoc to the quarries, the earnings from slate traffic being wholly derived from the down trains, although, by the usual railway fiction, the trains which really run all the way down hill, are, we believe, called "up trains." The carriage of slates returned £15,798 18s. 7d., equal to nearly 2s. 10d. per ton carried for the 13 miles down, or 2d. per ton per mile, and 13s. 6¼d. per down train per mile. The total receipts were £22,852 13s. 5d., or 9s. 9¾d. per train per mile in both directions. The working expenses were £9,700, or, say, 42 per cent. of the earnings; but of this sum, £1,223 were royalties paid under the name of "tonnages," £779 were parish rates, £382 passenger duty and income tax, £1,481 for station masters and staff, etc., the charge to locomotive department being £700 only. The actual locomotive expenses are very moderate, notwithstanding that with driving wheels but 2 ft. in diameter, and with coal at 15s. per ton, the cost of fuel is necessarily rather high. Thus it will be seen that the net profits of this little railway have

amounted to more than 40 per cent. of the original capital, and to upwards of 12½ per cent. on the total outlay on the undertaking, the larger portion of which has been paid out of revenue.—*Engineering.*

CHINESE TIME TABLE—VALUE OF KNOWING HOW TO READ.—The Chicago "Railway Review" notices a request from Samuel Lewis, who, we believe, is connected with the Western Pacific Railroad, either as an engineer or conductor—for copies of that paper for himself and friends. The "Review" appends this paragraph:

"Mr. Lewis incloses in his letter a quaint conglomeration of hieroglyphics on a half sheet—a Chinese time-table—which he says is used by Chinese conductors on the line, and which it is necessary for all conductors to learn. So, a candidate for a conductorship on these lines, we naturally infer, must acquire a more than ordinary degree of linguistic facility before he is competent to run a train west of Promontory."

Chinese time-tables may be very useful. But before this linguistic accomplishment is attained it might be well for railroad servants to know how to read English. We cannot vouch, for instance, that the switch-tender at Simpson's Station did not know how to read a Chinese time-table; but he could not read it in English, and this disability caused the loss of a dozen lives. A Chinese switch-tender, reading the time-table in his own tongue, would probably have arrested this dreadful calamity. But as the railroad servants are not Chinese, it might be well enough to begin with the acquisition of English first, and afterwards, if there is any gain, finish off in Chinese. Considering the number of accidents which have occurred since the first calamity, after reading Mr. Lewis's facetious description of what is required of a conductor, one might infer that Chinese time-tables are still used to the exclusion of any other.—*San Francisco Bulletin.*

A WONDERFUL TEAM.—On Saturday last there was seen on the streets of Leith a wonderful train of mechanism. It consisted of a ten-horse power road steamer, with two companions of equal size in tow to the docks for shipment. To those who have been in the habit of seeing heavy machinery dragged along by some sixteen or eighteen horses, and who have witnessed the kicking, plunging, swearing, and uproar which invariably accompany such undertakings, it must have been pleasant to observe the quiet smile on the driver's face as he silently picked his way along the street. Although the roads were in the worst possible condition, being thick with greasy mud, the journey to the ship's crane was effected so smoothly and easily that it did not offer a single incident for description. All that can be said of it is, that it was the simplest performance in the world. The road steamer, which was acting as tug to its two mates, was exhibiting its maiden effort, as it had only just been completed, and had never been out before. It is a ten-horse power engine, nominal, but can develop up to thirty-horse power. Its weight on the road is from eight to nine tons. The diameter of the wheels is 6 ft., the breadth of the india-rubber tyres is 15 in., their thickness is 4½ in. Messrs. T. M. Tennant and Co. (Limited), Bowershall, Leith, have obtained a license to manufacture Mr. R. W. Thomson's patent road steamers and steam omnibuses with india-rubber tyres, and they are making arrangements on a large scale to keep pace with the numerous orders received, and to turn out the engines with great dispatch.—*Engineering.*

PROGRESS OF FRENCH RAILWAYS. The Table which we subjoin shows the state of progress of the principal French lines at the end of last year.

NAME OF RAILWAY.	Number of Miles Open.	Number of Miles in Course of Construction.	Number of Miles for which Concessions have been Obtained, but which have not yet been Commenced	Total.
Paris, Lyon et Méditerranée	1510	569	782	3861
Orleans	2207	198	202	2707
Est	1667	194	102	1963
Ouest	1375	126	297	1798
Midi	1067	188	340	1595
Nord	891	60	52	1003
Charentes	73	22	290	385
Other companies	200	98	132	430
Totals	10,090	1455	2197	13,742

Besides these principal railways, there are to be found distributed in seventeen departments of France a number of cheaply constructed local lines, or "chemins d'intérêt local" as they are called, these lines having an aggregate length of 611 miles, and being in many instances of a narrower gauge than the lines forming the main network. There are also 33 "chemins industriels," connecting various mines and quarries with the main system, these lines having at the end of 1868 a total length of 103 miles, and an additional 6¼ miles being in course of construction. The longest of these lines is that extending from Commentry to the Canal du Berry near Montluçon, which is altogether about 12 miles in length.

Of the same class as the "chemins industriels" are the various branches belonging to the main lines, which serve to connect the latter with various mines, works, depôts, etc., and there are altogether 527 of these branches in France, their aggregate length being 170 miles. Of this total length 87 miles are worked by locomotives, 73 miles by horses, 11½ miles by manual labor, and 1½ miles by other systems of haulage. The greater number of the small branches we have mentioned belong to three of the principal railway companies, the Paris, Lyons, and Mediterranean having 156 branches, the Northern 129 branches, and the Eastern Railway 109 branches. The Paris and Orleans Railway, the second longest line in France, has but 39 of these small branches.

The total net receipts (after deduction of duty of 10 per cent.) on the French lines during 1868 was £27,320,000 or about 2,707 per mile, a sum which closely agrees with the receipts on the lines of the United Kingdom during the years 1867-8. In this latter year there were 14,247 miles of line open in the United Kingdom, and the total traffic receipts were £39,479,999 or £2,270 per mile, while last year the receipts per mile had increased to £2,960. The total number of passengers carried by the French railways during 1868 was 94,000,000, against 287,631,113 carried by our own lines dur-

ing 1867, and the working expenses amounted in 1868 to 47.8 per cent. of the receipts on the French lines, and 49.5 per cent. of the receipts on the lines of the United Kingdom. In conclusion, we give the following details of the traffic and receipts, etc., on the French lines during 1868, which we think are of sufficient interest to warrant our recording them:

Total weight of goods carried	47,500,000 tons
Mean distance traversed by each ton of goods	80.7 miles
Mean distance traversed by each passenger	24.8 "
Passenger train mileage	2,342,400,000 "
Slow goods train	3,852,500,000 "
Total train mileage of all kinds	6,871,120,000 "
Mean receipt per train per mile	96.6d.
" expenditure " "	45.9d.
" charge per mile per passenger	0.95d.
Mean charge per mile per ton	0.96d.
" net earnings per train per mile	50.07d.

—*Engineering.*

Railways and Climate.—It is said that the Pacific Railroad is working a great change in the climate of the Plains. Instead of continuous droughts, all along the railroad, rain now falls in refreshing abundance. In Central Ohio, for example, it is said the climate has been completely revolutionized since iron rails have formed a network all over that region. Instead of the destructive droughts formerly sufferered there, for some four or five years there has been rain in abundance —even more than enough to supply all the wants of farmers. This change is thought to be the result of an equilibrium produced in the electrical currents, which has brought about a more uniform dispensation of the rain It is a fact within the observation of all who remember anti-railroad times, that there are now few or no such thunderstorms as formerly took place in New England.

Locomotive Statistics.—The following is the report of the general average of performance of locomotives on all divisions of the Michigan Central Railway for the month of October, 1869, as made by A. S. Sweet, Locomotive Superintendent:

Number of freight cars drawn one mile..	2,127,772
Equal to cars drawn over the entire line.	7,492
No. freight cars drawn one mile in Sept.	1,973,568
Equal to cars drawn over entire line Sept.	6,949
No. miles run to one pint of oil	15.11
" " " " " cord of wood	33.38
" " " " " pint of oil in Sept..	15.38
" " " " " cord of wood	35.22
Average of freight trains	23.65
" " " " in September	21.04
No. of gallons of oil used	1,807
" " cords of wood used	4,857
" " tons of coal used	1,643
Average number of miles run per ton by coal-burning engines	35.99
Average number of miles run to one ton of coal in September	39.55
No. of miles run by passenger trains	76.783
" " " freight trains	96,307
" " " miscellan's trains	13,374
" " " training engines	32,080
Total	218,544

Bridges on the Burlington and Missouri Railway.—Whatever the degree of security attained in the road bed, a line crossing five or six hundred bridges must show no inferior excellence here. The problem was, of course, that of wooden bridges to start with, there not being time to construct stone ones (even if the material were everywhere at hand), and the expensiveness of iron putting it out of the question. The bridges, so far as concerns the needs of the road for several years, are most emphatically first class. The design, original with the engineer, exactly meets the circumstances of the case, and its excellence needs no higher verification to those who cannot visit the road, than the fact that it has been adopted on the Union Pacific, the Superintendent of Construction of which road was for some time Mr. Thielsen's assistant here. They all rest on pile or stone foundations, the low bridges (from 12 to 16 ft. high) on piles; beyond that height they become "bent" bridges of one, two, and even three "stories," resting either on pile or stone foundation. The peculiar feature is the manner in which the superstructure is bound together, so as to make it as emphatically *one* structure as the best iron bridge can be. The span of the trestle are either 16 or 20 ft.; upon the caps rests a system of stringers, varying from 6 to 8 in number under the track; the dimensions of the timbers being, on the 16-ft. span, 5 x 16 in., and on the 20-ft. span, 6 x 16 in. These stringers only reach from bent to bent, abutting against each other; and the different sets are from 14 to 16 in. apart from centre to centre. In these openings, and resting upon the cap, is a splice of the same size, but only half the length of the stringers, locked down upon the cap 1¼ in,, both splices and stringers being bolted together. In the intermediate spaces the bolts pass through cast-iron washers, keeping everything in position, which, when the nuts are screwed on, bury their sharp edges in the wood, binding the whole into one mass. The strength of this simple and admirable splice has undergone an *experimentum crucis*, in the case of a train passing rapidly over a span, the bent beneath which was afterward found to have been washed out. Upon the stringers are placed the ties, 16 to every 20 ft., which, in turn, are held in position by longitudinal fenders, slotted down upon them; the whole fastened to the stringers with fender bolts passing through fender, tie, and stringer, every 8 ft. In passing over the bridges the engineers feel under no necessity to materially slacken speed, and the structure is free from perceptible vibration beneath the heaviest or swiftest train. Over the larger rivers the length of the bridges is about 1,200 ft., that over the Des Moines being half a mile. After leaving the bridge, the embankments are broken up at regular intervals with trestle work, to give the freshet overflow a free communication to all parts of the bottom. The bridges, except those built the past season, are nearly all inclosed above. The bridge connecting the C. B. & Q. and B. & M. R. R, was finished in 1868; is of iron, 2,200 ft. long; has 9 spans of 250 ft. each, the draw being 360 ft.—*Chicago Railway Review.*

Snow on the Union Pacific Railway.—In the matter of snow protection, what has been done is, in brief, this: At all exposed points, permanent sheds, 8 miles in all, will be completed by Jan. 20; by which time 150 miles of snow fence will be completed. The force engaged for six weeks on

this work has numbered 300 men. The fence, of original design, and answering the end perfectly, merits a description. The supports (8 ft. apart) consist of two posts (2 x 6 in., 8 ft. long) joined together (by means of a bolt) in the shape of an X, at about one-third of the distance from their top. On the outside of these, common fence boards are nailed—three on the upper part of the one and four on the lower part of the other. In most places, *two* of these fences are built—the outer 100 feet from that nearest the track. The protection is perfect.—*Chicago Railway Review.*

ORDNANCE AND NAVAL NOTES.

PALLISER CONVERTED GUNS.—The complete success which has attended the conversion of upwards of 400 cast-iron 8 in. smooth-bores into Palliser rifled cannon for the Admiralty has lately attracted the attention of the War Office to the importance of converting the thousands of 68-pounder cast-iron guns which are mounted on our coast defences both at home and abroad. Out of several hundred guns which have now been proved, in no instance has the slightest symptom of weakness presented itself. These conversions are due to the reports and recommendations of General Lefroy and the members of the late Ordnance Committee, and the practical results reflected great credit upon their labors. The recent visit of Colonel Jervois, the Deputy-Director of Fortifications, to Halifax and Bermuda has been the means of further demonstrating the importance of the subject. It appears that at the latter place alone upwards of 300 smooth-bore guns are mounted in the works, and although complete in their carriages, traversing platforms, embrasures, sponges, rammers, etc., they are, in their present smooth-bore state, no better than wooden dummies for opposing a bombardment at long ranges with rifled guns. The Secretary of State for War has, as a preliminary measure, authorized the trial at Shoeburyness of two rifled guns, a 7 in. and an 8 in. converted from 68-pounder guns. They are to be fired at the "Warrior" target from a distance of 1,000 yards. The experiment is awaited with great interest, since if the guns penetrate the target at such a range, it is expected considerable orders for conversions will follow. An old cast-iron mortar has also been converted, by Mr. Cardwell's directions, into a 9 in. rifled mortar, and will be tried at the same time as the guns. It weighs about 6 tons, and it is expected that it will throw its shell of 250 lbs., containing a bursting charge of 20 lbs. of powder, upwards of 7,000 yards.—*Mechanics' Magazine.*

EXPERIMENTS AT SHOEBURYNESS.—A further short trial of four rounds was made at Shoeburyness on Wednesday to test the clutch arrangement of the screw compressor head of Vavasseur's 7 in. steel gun-carriage, alluded to in our former notice of November 26.

The details of the rounds were as follows:

Round	Elevation.	Charges l. g. r.	shot	Compressor at	Recoil ft. in.	Time of Flight.
1..	7 deg. ..	14 lbs. ..	114¾lbs. ..	2½ ..	0.5 ..	9.3 secs.
2..	7 deg. ..	14 lbs. ..	114¾lbs. ..	2 ..	0.6¼ ..	9.3 secs.
3..	7 deg. ..	22 lbs. ..	114¾lbs. ..	2 ..	1.7½ ..	9.5 secs.
4..	7 deg. ..	22 lbs. ..	114¾lbs. ..	2 ..	1.0 ..	9.8 secs.

In the above practice the slide drove back at each discharge about 4 in., in consequence of the bad holding afforded by the marshy ground, and in this way was gradually carried off the racers on to the platform, rendering exactitude of recoil out of the question. It was clear, however, that the clutch arrangement effectually answered its purpose of securing the mechanical hold of the coned head on the friction drum during the recoil of the gun.

Including Wednesday's practice, the total fired is now 145 rounds, composed of the following items:—2 proof rounds of 27 lbs., at Woolwich Arsenal; 10 service charges of 14 lbs., and 9 battering charges of 22 lbs., at Yarmouth; 50 battering charges at Woolwich; 56 battering charges at Portsmouth; and 8 service charges and 10 battering charges at Shoeburyness. The gutta-percha impressions taken after the last previous practice show no sign of wear in the gun.—*Army and Navy Gazette.*

ACHILLES, 26, screw armor-plated ship, Captain Mathew S. Nolloth, coast-guard ship at Portland. On the 27th ult. this ship went outside the breakwater at Portland for the final trial of the patent hydrostatic steering apparatus invented by Rear-Admiral Inglefield, C.B., and which has been recently fitted to the Achilles. It was then, as upon former occasions, clearly shown that by its use one man in the pilot-house on the bridge can put the helm over the largest ship, when going at full speed, in a space of time and with a power that has never been approached by the efforts of forty men exerted on the ordinary steering wheel, and not surpassed by the steam steering gear which is applied to the Northumberland, employing still the ancient appliances of long tiller and ropes, etc. It may be asked, What are the advantages of the power the Admiral employs as a motor over steam? And this may be briefly answered thus: In the first place, he utilizes an enormous accumulative power which exists outside of every floating vessel, whether at rest or in motion, that power being greater in proportion to her depth of immersion. Thus, a ship like the Achilles, drawing 26 ft. of water, can utilize an external pressure of water at the bottom of the vessel equal to from 8 to 10 lbs. on the square in. To make this available for the purposes of steering the vessel, the Admiral admits water through a Kingston valve in the bottom of the ship to a cylinder lying on the keel. An internal piston, moving by the pressure due to the column of water, and made to change its direction by a self-acting reciprocating movement, conveys the power to a ram, which multiplies the pressure first obtained in proportion to the areas, and from thence through two 2-in. pipes, conveys a column of water at a mean pressure of 300 lbs. on the square in. to hydraulic presses, which act on the lower tiller at a radius of 4 ft. from the rudder-head. The power is directed to either side of this short tiller by means of a directing slide, which is moved by a long rod set in action by the small wheel in the pilot-house. At either extreme of its movement, which does not exceed 5 in., the high-pressure water is forced to either the starboard or port tiller cylinder, putting the helm over with an irresistible force in the opposite direction. At the middle part of the movement of the directing slide, a free communication is opened between the two tiller cylinders, and then the rudder will right itself when the ship is going through the water. At this position, too, the ordinary steering wheel

may be used, as though the new apparatus did not exist. On the lower deck there is a corresponding small wheel to the one in the pilot-house, to be used when the ship is in action. These wheels are used in precisely the same manner as the ordinary wheel, the only difference being that from hard a-starboard to hard a-port it has only to be made to revolve ⅕ths of its whole circumference. The advantages claimed by the inventor over all steam steering apparatus are these: 1. The water engine placed on the keel of the ship, in a spot unoccupied by anything else, requires no personal superintendence; it is always ready at a moment's notice, and costs nothing to keep. 2. Water, being incondensible and incompressible, is more suited for the working of an apparatus which may lie almost completely idle for hours, but must, nevertheless, be ready for use at the shortest notice, and to its fullest extent. 3. As a fighting gear for the helm, it possesses the property of requiring the smallest tiller possible, with an attachment placed more completely out of gunshot than any yet invented. The official report of the trial of the Achilles, on June 23, set forth the following advantages and shortcomings: 1. Sufficient motive power always available. 2. The steadiness with which the power applied overcomes the resistance of the rudder at the highest rate of speed, especially when the helm is nearly hard over. 3. The security with which the rudder is held at any desired point. 4. The readiness with which the rudder is freed after being hard over, and thereby allowed to right itself rapidly when going at speed. 5. The ease with which the power is applied, one man being able to use it under any circumstances. 6. The facility with which the tiller is connected with, or disconnected from, the hydraulic rams. The defects of the apparatus appear to be at present: 1. Want of rapidity in action. A certain limit of time for the process of putting the helm hard over from amidships should be made an indispensable requisite—not more than 45 seconds, and not less than 30 seconds. 2. The egress of the water from the pumping engine to the bilge is not sufficiently free. These shortcomings have been fully overcome by the improvements made since the date of that trial, for it was reported then that the helm went over every time to about 25 degs. in 10 seconds, the maximum angle obtained by the ordinary wheel being 24½ degs. in 1 minute and 17 seconds. The pumping engine has been much improved; but it is intended in the Turkish iron-clad, which is now being fitted with Admiral Inglefield's apparatus, on the recommendation of the Chief Constructor of the Navy (Mr. Reed), to put a far simpler and less expensive form of water-engine.—*Army and Navy Gazette.*

ENGINEERING STRUCTURES.

Strength of Unstayed Flat Surfaces to Resist Pressure.—At a recent meeting of the Liverpool Polytechnic Society, Mr. Lauder read a paper, of which the following is an abstract, entitled "Strength of Unstayed Flat Surfaces under Pressure."

The object of this paper is to lay before the Society some considerations that guided the writer in designing a digester under somewhat unusual conditions, for the firm of Messrs. Rose & Gibson, to be used in their new process of utilizing cotton seed.

The conditions required to be fulfilled were that the bottom should be flat, that there should be no internal stays, and that it should be sufficient to withstand a working pressure of 30 lbs. per square inch. The *factor of safety*, determined on from the nature of the work to be performed, was the same as that in common use for steam boilers, viz., 8. Thus, the bursting pressure is 240 lbs. per square inch. The method of strengthening the bottom by outside girders was selected in preference to bracing, for the sake of convenience with regard to the position it had to occupy. The distance of the girders from each other is one foot from centre to centre. The girders are proportioned so as to resist the entire pressure on the bottom of the vessel, each girder supporting a load of the amount of the pressure on a surface equal to the length by the distance between two girders. It is worth observing that the bottom of the vessel serves also for the top booms of the girders. The next point to be considered is the thickness of the bottom, to ascertain that it is strong enough between the girders to sustain the pressure without staying. The portion under consideration is evidently in the condition of a rectangular beam fixed at the ends, and is consequently simply under the laws which govern the breaking of beams. For calculation it is convenient and sufficient to consider a strip one inch broad, stretching between the girders. The advantage arising from end fastenings being neglected, we find a very simple adaptation of the ordinary formula for the strength of girders leads to a general formula for surfaces under such conditions: t = thickness of plate; c = half distance between supports; f = modulus of rupture—wrought-iron bars = 54,000; cast-iron bars = 33,000 to 43,500; W = bursting pressure on a strip unit breadth between supports; p = bursting pressure.

$$t^2 = \frac{c\,W}{\frac{1}{3}f}$$

$$\text{But } W = p \times 2c.$$

$$\therefore t^2 = \frac{p \times 2c}{\frac{1}{3}f}$$

—*The Engineer.*

The Well at Prospect Park.—The great well of Prospect Park, Brooklyn, built under the direction of C. C. Martin, the engineer, is thus described in the "New York Times:"

"The outer wall is fifty feet in diameter, two feet thick, and fifty-four feet high. The inner curb, or wall, is thirty-five feet in diameter and two feet thick, having a depth of ten feet. The masonry, as seen from the top of the structure, is a marvel of neatness and solidity. The water surface in the well is thirteen feet above high-tide level, and the depth of water in the well is fourteen feet. The pump foundations are entirely independent of the walls. This plan was adopted so as to obviate any possible difficulty which might arise from displacement. The pump is the Worthington patent, and, with a pressure of forty pounds, is capable of raising one million gallons of water every twenty-four hours a height of 176 feet, and is competent to a lift of 180 feet.

"The boiler house is a neat, pressed-brick structure trimmed with Ohio stone, standing on the surface near the mouth of the well. The interior

of the well is reached by a spiral stairway built in the wall, and commencing in the boiler house. In this way the engineer is able to reach the pump. It is a fact worthy of notice in connection with the construction of the wall, or rather the sinking of it, that the outer wall rests upon four feet of wooden cribwork, two feet thick, and having an iron shield. The inner wall is built upon a similar crib only two feet deep, also shielded with iron.

"The Commissioners were led to the construction of this well in presence of the danger at any time of some accident taking place in connection with the Brooklyn Water Works, which would render it necessary for the Water Board to cut off the Park supply so as to secure the citizens from suffering. This well has more than the necessary capacity to supply the Park abundantly with water, yielding most when most is needed. This is established by the discovery that the time of drought from which the well is, or may be, likely to suffer, occurs in the Fall. Besides these facts, it further appears that in order to furnish the supply of water to the Park the Water Board would have to go through the process of pumping their water twice to convey it to the required elevation, equal to 225 ft. from its original level.

"The work of the well will be to supply the pools at an elevation of 133 ft. From the pools the water is conducted to the lake. Besides this, there is an independent connection with the lake by which, as necessity may suggest, the water can be directed to the lake, a lift of only 70 ft. The lake, when completed, will occupy an area of fifty acres, which will be kept continually supplied with fresh water, the arrangements being such, or to be such, as will insure a permanent change of water, and prevent any of the evils that may arise from stagnancy. The well is fed from the earth, consisting of a circuit of 2 miles, with a fall of 5 ft. to the mile. For this reason it does not appear easy to exhaust the supply, as when the water is pumped out to 4 or 5 ft. from the surface of the well, it is replaced at a rate equal to the demand. Every allowance has been made for evaporation from the lake and pools, and the supply is regarded as inexhaustible. Another important fact here suggests itself; that is, that sufficient rain falls during the season in the area of 2 miles around the well to make the supply perennial. The Prospect Park well is a credit to Brooklyn.

Braced Arches and Suspension Bridges.—At a meeting of the Royal Scottish Society of Arts held at Edinburgh on Monday night, a communication was read on "Braced Arches and Suspension Bridges," by Mr. Jenkin, Professor of Civil Engineering in the University of Edinburgh. The Professor stated that the experiments made in connection with the Britannia Bridge had established the theory of metal girders on a sure practical basis, and with the inquiry of a Royal Commission into the application of iron to railway structures, had led not only to the general adoption of the iron girder as an convenient type of bridge, but also to a widespread belief that essentially the girder is a cheaper and lighter form of support than the metal arch. The suspension bridge, indeed, the theory of which was identical with that of the arch, was known to be a lighter form of support than the girder; but an impression prevailed that the flexibility of the form could not be really overcome without sacrificing the lightness; and although this prejudice had been gradually yielding, the assertion that a stiff suspension bridge might be advantageously used for moderate spans would be received with doubt, while a statement that a cast-iron arch might not only be safely used for spans of 700 or 800 ft., but would be lighter than a girder for ordinary spans, would excite simple incredulity among practical men. Calculation showed that there was no essential superiority in the girder over the two other forms; but the adoption of braced arches and braced suspension bridges had been very materially retarded by the difficulty in making the necessary calculations as to the strains to the parts. In speaking of braced ribs, the Professor said the exact determination of the state of stress at different points became a problem of almost impracticable perplexity. He gave in his paper a method, founded upon a theory due to Professor Clark Maxwell, by which the necessary calculations could be made without extreme difficulty. These calculations had led to some novel and important results, showing a distribution of material in braced ribs or suspension bridges different from that hitherto employed. Thus, a chain of a braced suspension bridge, of a form which was exhibited in model, should be deeper at the middle to less than one-fourth of its cross section to the pier, and the bottom member also holding tension, should be increased in the ratio of 1 to 10 from the piers to the centre, where it should have nearly the cross section of the top chain at the pier. The arch should be designed with the same distribution of metal. Tables exhibiting the results of a comparison between arches and girders showed a great superiority in the arch or inverted arch. When a series of arches was designed, the thrust of one loaded arch could easily be provided for without greatly straining its unloaded neighbor. The paper was illustrated by models, one of which showed the perfect stiffness of a suspension bridge in which the top member was a chain, and the bottom member a straight tie parallel with the roadway. After discussion, the paper was referred to a committee.—*The Building News.*

Hell Gate—Proposed Canal through Astoria.—No one denies the fact that great advantages would accrue to our coasting trade, if the obstructions at Hell Gate were removed, and a safe channel laid out, available at all times of the tide. The work of Prof. Maillefert has already lessened the dangers of navigation in that locality, and the Government is making an effort in this direction also—which, however, it is thought by many will involve a vast expenditure of money and extend over a period of many years. Mr. W. W. Vanderbilt, late Constructing Engineer of the Pacific Mail Steamship Company, has conceived a plan for excavating a canal through the promontory upon which Astoria stands, and thereby forming a straight course from the East River to the entrance of the Sound, thus avoiding the crooked and dangerous channel now used by crafts in entering the Sound from New York, and *vice versa*. At first glance this is a startling proposition; yet upon examination the plan appears not only feasible, but far more economical than any yet put forward. The work could be accomplished with certainty, regardless of tide and weather, and could be completed inside of two years, at an estimated cost of not exceeding $3,000,000. The channel proposed would be about 2,000 ft. in length, 600 ft. in

breadth, equal to the width between Blackwell's Island and the Long Island shore, and with a depth at low tide of 34 ft., so that vessels of any draft and tonnage could pass through at all times of tide, and by night as well as day, in perfect safety. The point cut off from the main land could be appropriately used for the storage of petroleum and like inflammable stuff, or for a variety of other purposes. It is true, as the scheme now stands, the canal would strike through some valuable property; still the general plan is not incapable of modification by shifting the channel further to the westward, so as to bring it in line with the westward channel of Blackwell's Island, and then removing the extreme end of the promontory, around which at present the water rushes with mill stream velocity. The plan has many good points. Some of the most intelligent of the Hell Gate pilots who have seen the drawings, speak openly in its favor, and many engineers and practical men also indorse it. As yet no carefully prepared estimates have been made, nor comparison with the proposed work of Gen. Newton, the United States Engineer; but it is safe to say that the cost of the Government work would be double, if not treble, that of Mr. Vanderbilt. Parties are looking into the matter with a seriousness that indicates a possibility that something may yet be done in this locality which will be of enduring benefit to our marine interests, and at a reasonable cost.—*Gas Light Journal.*

A Ship Canal across Cape Cod.—We learn that a party of capitalists of ample means have organized their resources for the purpose of constructing a ship canal across Cape Cod, a project that has been much discussed, but which has never before assumed a practical shape. It is contemplated to build the canal in nearly a direct line from Buzzard's Bay to Cape Cod Bay, through a narrow neck of land separating those waters, which shall afford a sufficient depth of water to float the largest class of vessels. The canal will be 300 ft. wide, and deep enough to insure 24 ft. of water at low tide. A company has been formed to carry out the enterprise, the land surveyed, and other preliminary measures taken, and they now only await a charter from the Legislature for requisite authority to commence the undertaking. It is stated that the persons who propose to achieve this important work are fully prepared to carry it out, and ask for no pecuniary aid from the State in furtherance of the object. The great value of the proposed canal to the commercial interests of Massachusetts will undoubtedly commend it to public favor, as the importance of such a work has often been shown during the past few years.—*Boston Journal.*

NEW BOOKS.

The Midnight Sky—Familiar Notes on the Stars and Planets. By Edwin Dunkin, F. R.A.S., of the Royal Observatory at Greenwich. London: Religious Tract Society. 1869. For sale by D. Van Nostrand.

Although this work can in no way be considered as a rival to Mr. Proctor's excellent Star Maps, it is nevertheless one which must take a high rank of its own, and which appeals especially to the lover of popular science. It is certainly one of the best things which the Religious Tract Society has ever published, and we congratulate the Society on the fact. The author has sought to produce a general treatise on astronomy which shall at the same time contain a series of star maps useful to the amateur; and he has succeeded very well in his efforts. The ample quotations we have already made from the work elsewhere will be sufficient to show our readers the character of the book, and the clearness of Mr. Dunkin's style. But they cannot gather from them the character of his star maps, which is indeed somewhat peculiar. His aim has been to depict the sky just as a Londoner would see it during the various months of the year; and his method of execution, though not rigidly scientific, is still enough so for all practical purposes, and it has the great merit that it can be studied and understood, even by the most uninitiated. Indeed, one who knew nothing at all of astronomy could, in the course of a few bright nights, become familiar with all the constellations from this handsome volume. Let us take the first four illustrations as an example. Here we have two quarto plates. On the upper part of one is represented on a black ground the midnight sky of London, looking north, as seen on January 15. The stars are not named in the illustration, but below it is a small key or index map which enables the observer at a glance to find out the stars of greater magnitude. The second plate shows us the midnight sky of London, looking south, for the same date. In the lower part of each plate are shown the characteristic buildings, scenery, etc., of the locality from which the astronomer is supposed to take his observations. Thus, in the first we see St. Paul's and the different structures which lie in its neighborhood; and in the second, the Royal Observatory and the Hospital of Greenwich stand prominently forward. Pursuing this plan, the author deals thus with every month in the year, and furnishes, as we have said, a simple and intelligible series of star maps, which are described with some minuteness in the text.

Having treated in this way of the midnight sky as seen in the northern hemisphere, he next passes on to the sky of the southern hemisphere, and deals with it in an equally liberal spirit. Then follow the accounts of the constellations, considered independently, and of the Sun, Moon (including eclipses), the terrestrial planets, the Earth, the planetoids and the major planets, comets, and meteors; and lastly, a short chapter on Astronomy and the Bible. In all his descriptions the author is clear and popular, and not inaccurate; and for these reasons we have pleasure in recommending the work. The chapter on Biblical matters is the only one to which we object; we presume its introduction was unavoidable, but we must say that, however well intentioned, it is creditable to neither the author nor Modern Astronomy.—*Scientific Opinion.*

The Strains on Structures of Iron-Work. With Practical Remarks on Iron Construction. By F. W. Shields, M. Inst. C. E. Second edition. London: John Weale, 1867. For sale by D. Van Nostrand.

The methods of computation in this work are arithmetical, but are sufficiently comprehensive for the varieties of bracing discussed.

The Warren girder receives its full share of attention.

The Bowstring girder, with and without vertical struts, as well as the forms of bracing most

frequently applied to iron roofs in this country, are treated in a manner which requires no familiarity with the higher mathematics to comprehend.

The practical remarks on Iron Construction are too brief to be of much value.

Five well-executed plates illustrate the work.

THE SUN. By AMÉDÉE GUILLEMIN. From the French, by T. L. PHIPSON, Ph.D. London: Bentley, 1870. For sale by D. Van Nostrand.

M. Guillemin's work on "The Heavens," which was introduced to the English public some years since by Mr. J. Norman Lockyer, was so deservedly popular a book that, naturally, the present volume will be received with no little favor. But we fear that readers of "The Heavens" will be somewhat disappointed with "The Sun." Somewhat, we say; because, as a general treatise, it is not, in our opinion, to be compared to the earlier work. It must not, however, on that account, be imagined that the present volume is not a good one, and is not full of matter just now of especial interest to the educated public.

REPORT ON THE FILTRATION OF RIVER WATERS, for the supply of cities, as practised in Europe, made to the Board of Water Commissioners of the city of St. Louis. By James P. Kirkwood, C. E. 1 vol. 4to, 178 pp. and 33 Lithographed Engravings.—D. Van Nostrand, Publisher.

This subject, one but little understood with us, has received the most careful attention from the Engineer of the St. Louis Water-Works, Mr. Kirkwood, in an elaborate Report to the Commissioners of that work, published in a quarto volume with copious illustrations.

The water supply of an inland city must be sought for mainly in river water, with more or less inorganic impurities, which admit of ready separation by the proper means; what those means are, we have no precedent at hand for determining. It is in the experience of the oldest cities of Europe alone, that the data can be found to meet the future wants of our growing cities, and Mr. Kirkwood, after a careful examination of the prominent water-works of Europe, has given us the result of his labors, which will prove a standard work on the subject of filtration.

Although nominally a Report on Filtration, it at the same time embraces the characteristics of the various water-works examined, including the nature and extent of supply, the power used, and the nature of its application; fuel, consumption and cost; work done in water raised to a given height—in fact, all the details essential to the complete elucidation of the subject of water supply in the following localities: London, embracing Chelsea, Lambeth, Southwark, and Vauxhall Water-Works, Grand Junction, West Middlesex, New River and East London, Wakefield, Leicester, York, Liverpool, Edinburgh, Dublin, Perth, Berlin, Hamburg, Altona, Tours, Angers, Nantes, Lyons, Toulouse, Marseilles, Genoa, and Leghorn. The illustrations are very clear and precise, and the work fills a gap long existing in the literature of the profession of civil engineering.

AN INTRODUCTION TO THE SCIENCE OF HEAT, designed for the use of schools and candidates for University Matriculation Examinations. By TEMPLE AUGUSTUS ORME, Teacher of Chemistry and Experimental Physics, University College School, London. London: Groombridge & Sons. 1869. For sale by Van Nostrand.

The author discusses his subject in twelve chapters, and treats of Expansion and Conduction in Solids; Expansion, Conduction, and Convection in Liquids and in Gases; Evaporation and Liquefaction; Relative (or Specific) Heat; Nature of Heat; Connections between the Sciences of Heat and Chemistry; Radiation. We will try to include within our allotted space a word on the treatment of each of these subjects.

In the introductory remarks on Expansion the author puts himself the questions: "How is it that substances do not expand without being heated? and, How is it they do expand when heated?" and, of course, gives an answer to them. This he does by referring to cohesion as a force to be overcome by the heat. We are inclined to call this very old-fashioned teaching, and poor philosophy—quite out of place in a work so generally excellent as we find this little book to be. Our answer to the above questions would be: We do not know how; the facts are so, that is all we can say.

On conduction by solids, we find the author careful to be accurate in his teaching, and the same is true throughout the boook. We will here quote him:—

"If two similar bars, one of copper and the other of iron, are heated at one end, the opposite end of the copper bar will become hot long before the corresponding end of the iron bar. It is very natural to conclude from this that copper is a better conductor of heat than iron is; but it will be shown in a future chapter that this is by no means a logical conclusion."

It is afterwards pointed out to the student that the rate of transmission of heat depends upon the relative heat of the body as well as its conductivity.

Under expansion of liquids the effects of temperature on the height of the barometer, and the calculations they make necessary for the correct reading of the pressure of the atmosphere, are carefully considered; we think, however, there is room for a simpler treatment than it receives of this not very difficult subject.

Ventilation, atmospheric currents, relative weight (specific gravity) of gases and vapors (and the methods of taking it) are included and clearly described in the chapter on expansion of gases. The chapters on evaporation and liquefaction are also to be commended; they of course, include an account of latent, or, as it is here called, potential, heat, and the tension of vapors.

The difficulties generally felt by the student in mastering the subject of specific or relative heat will, we think, be found to be almost entirely removed, in consequence of the methodical treatment it here receives. The chapter on the nature of heat is an account of the reciprocal convertibility of heat and mechanical force, and the conclusion from this fact, that "heat is a mode of motion." It says nothing, we are glad to add, of that subtle fluid, caloric, on which writers have been so fond of dilating. In the remaining chapter, radiation and absorption of heat and the diathermanency of bodies are described.

Mr. Orme's little treatise appears to us to be an excellent text-book, meeting a want, and we congratulate him on its production.—*Scientific Opinion.*

WEISBACH'S MECHANICS: A Manual of the Mechanics of Engineering and of the Construction of Machines, with an Introduction to the Calculus, designed as a text-book for Technical Schools and Colleges, and for the use of Engineers, Architects, etc., by JULIUS WEISBACH, Ph.D., Oberbergrath and Professor at the Royal Mining Academy at Freiberg; Member of the Imperial Academy of Sciences at St. Petersburg, etc. In 3 vols. Vol. I., Theoretical Mechanics, with 902 wood-cuts in the text. Translated from the fourth augmented and improved German edition, by Eckley B. Coxe, A. M., Mining Engineer. 1,112 pages, 8vo. New York, 1870. D. Van Nostrand, Publisher.

An English translation of the first edition of this work, published in two volumes over twenty years ago, though poor as a translation, has yet been so extensively used, and of late commanded so high a price, as to show conclusively the very great excellence of the work itself in the estimation of teachers and engineers. All who have known either the original or the translation named, will be glad to learn that the new translation, the first half volume of which is now before us, besides being made from the fourth greatly enlarged and improved German edition, is also, as a translation, a great improvement on the old one, and, in some respects, is an improvement on the original itself, being made under the author's sanction, and embodying the latest corrections of both author and translator. This part, issued in advance of the complete volume, to meet the immediate demand for it as a text-book, includes the four sections: 1, Simple Motion; 2, Mechanics, or the Physical Science of Motion in general; 3, Statics of Rigid Bodies, and 4, the Application of Statics to the Elasticity and Strength of Bodies; together with a preliminary introduction to the Calculus. The use of the Calculus in this edition has involved the recasting of large portions of the work, as, especially, in the fourth section of this part. The entire work will, like the original, fill three octavo volumes of ten or twelve hundred pages each. Though too extensive, perhaps, and difficult for many besides special students and professional engineers, it will still, we hope, meet with such favor as to remunerate the enterprising publishers for undertaking to place before the country this invaluable Thesaurus of Theoretical and Applied Mechanics.—*American Journal of Science and Art.*

MISCELLANEOUS.

NEW THERMO-ELECTRIC PILE OF M. MURE & CLAMOND.—This thermo-electric pile, because of the intensity of the current and its economy, can be usefully employed in divers applications. It is made up of 60 elements. These consist of small bars of lead, or native sulphuret of lead, and of plates of steel. The bars are 40 millimetres long by 8 thick, and the plates of steel are 55 millimetres long by 8 broad, and 0.6 thick.

In these couples galena is the electro-negative element; iron, the electro-positive. The form of the bars is such that by placing them side by side, they form a ring of 12 couples, of which the interior is formed by the extremities which are to be heated. They are united in tension by means of tin solder. They are isolated from one another by thin mica plates. By placing 5 of these rings in a vertical column, a battery of 60 couples is formed. These rings are isolated and separated by washers of asbestos. The whole is firmly held between 2 iron rings by means of 3 bolts.

The pile thus forms a hollow cylinder, the interior of which must be heated. The cooling of the junctions, whose temperature should be lower, is caused by radiation into the air. The interior cylinder measures 50 millimetres in diameter and about the same in height. The heated surface is about 78 sq. centimetres. The apparatus is heated by a gas burner, consisting of a steel cylinder 55 millimetres in diameter, closed above, open below, and pierced with small orifices. This is placed in the centre of the pile. A tube pierced with holes surrounds this cylinder and distributes the gas uniformly around it. The gas rises, and arriving at the orifices in the burner, meets the air which is escaping from it because of the draft of the tube of steel that surrounds the apparatus. Each orifice in the burner thus forms a blowpipe, the jet of which strikes the opposite side.

Forty couples have an electro-motive force equal to that of a Bunsen element. Its interior resistance to cold is that of a copper wire 9.85 millimetres, and 1 millimetre in diameter. But during its action, it increases and becomes equal to 22 metres. The current is intense in proportion to the feebleness of resistance.

Visible sparks are obtained between the two electrodes. The current reddens a platinum wire 0.3 mil. in diameter a length of 35 mil. It also decomposes water.

This pile, acting for 10 consecutive hours, consumed 785 litres of gas, at an expense of 2 centimes and a half an hour. It is, therefore, an economical generator of electricity.—*Le Génie Industriel.*

MISSOURI TIN. About two years ago considerable interest was manifested in regard to the discovery of very extensive deposits of tin ore in this State, and land owners and speculators were accused of having the "Tin Fever." Weeks and months were spent by prospecting parties, and all the tin lands that could be purchased at reasonable rates changed hands. One company was organized, invested about $30,000 in tunnelling the hill and in work preparatory to the erection of a furnace. But their work has been stopped for several months—whether from want of capital, or energy and enterprise, we are not informed. Meanwhile, they have discovered tin ore in California, which is said to be inferior to the Missouri ore, and we now see by a California paper, that "The first article of tinware manufactured from tin mined in the United States has just been completed in San Francisco."

Numerous assays have been made of this ore by chemists and assayers of national reputation, who have repeatedly stated *here* that the ore will yield from 3 to 5 per cent. of pure tin; yet, when they reach the Atlantic cities, where the tin importers hold sway, they fail to find tin in paying quantities.

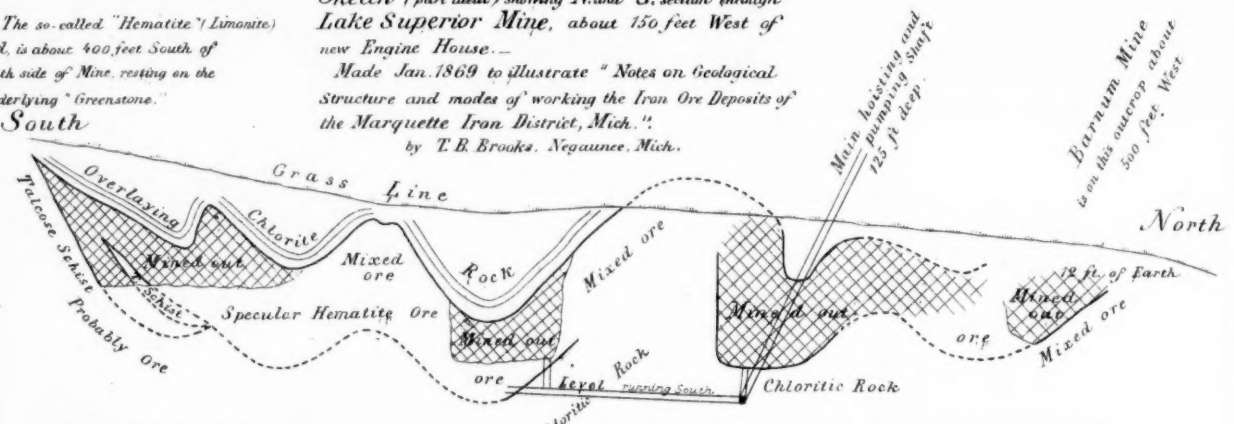
Chemical analysis and assays are not wanted now; but, instead, we need a furnace to smelt the prepared ore and produce the pigs and bars of tin. A test furnace need not be very expensive, and this question, if decided affirmatively, will be of the greatest importance to this city, State, and the whole nation, as the importation of foreign tin into the United States now amounts to from five to six million dollars annually, and is constantly increasing. Who can say that the practical investigation of this subject will not prove as satisfactory as the experiments in smelting iron with our native coals?—*The Iron Age.*

MARQUETTE MINING REGION. (p. 289.)

The so-called "Hematite" (Limonite) bed, is about 400 feet South of South side of Mine, resting on the underlying "Greenstone."

South

***Sketch** (part ideal) showing N. and S. section through **Lake Superior Mine**, about 150 feet West of new Engine House.—*
Made Jan. 1869 to illustrate "Notes on Geological Structure and modes of working the Iron Ore Deposits of the Marquette Iron District, Mich."
by T. B. Brooks, Negaunee, Mich.



Explanation. *The full lines are actual; - the dotted lines are conjectural. "Mixed ore" means pure specular hematite, intulaminated with quartz; some times the quartz is broken up so as to approach a breccia. The total length of Section that is width represented on sketch as underlayed by ore, is less than 600 feet, - which, so far as known, is the total width of the "hard ore" belt at this point. The axes of the folds, shown on this section, incline to the West. These axes sometimes undulate so abruptly, as to produce forms approaching a hemisphere, and in some instances "ear shaped" basins. From bottom of main shaft, levels running S. and E. found ore on all sides,— but levels running West and N.W. found no ore.*

Engraved for Van Nostrand's Engineering Magazine, 1870.